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Discussion of all papers is invited

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THE PROBLEM OF WATER SUPPLY FOR FIRE PROTECTION[1]

BY V. BERNARD SIEMS[2]

Our purpose here is to define the problem of water supply for fire protection and to sketch briefly its various phases, only suggesting topics which, it is hoped, will be developed by the discussion that follows. Provision for fire protection should be an important concern of the water works engineer, for it is admitted that such protection is one of the purposes of a water works system and the good that results from assigning to it its proper importance far exceeds the cost entailed. It is, therefore, assumed that fire protection facilities are desirable on the water works system and the manner in which such provision affects the design of the system will be outlined.

IMPOUNDING WORKS

Impounding works are a factor of the problem in the smaller communities only. In providing impounding capacity for the smaller community consideration should be given fire safety as well as the protection of life and health during drouth periods affecting a community's source of water supply, for it is also necessary to

[1] Presented before the Fire Protection and Plant Management and Operation Divisions, Louisville Convention, April 28, 1925.

[2] Water Engineer, City of Baltimore, Baltimore, Md.

guarantee reasonably the protection of a community's means of livelihood by protecting its plants and industries from destruction by fire. Therefore, sufficient impounding capacity for fire safety and a proper means for bringing this supply to the community must be provided, especially in small communities, where little or no distribution storage capacity is available, and in flat regions where probably there are no means of balancing the distribution system, other than perhaps by a standpipe.

If no balancing capacity is provided, sufficient pumping capacity should be provided for the peak load and in such cases adequate impounding storage is vital.

FEEDER MAINS

Feeder supply mains should be in duplicate, to guarantee continuity of service and this duplication should be carried out in supply lines, especially those leaving pumping stations.

PUMPING STATIONS

Pumping stations should be equipped with a sufficient number of units to supply the required demand, peak load consumption plus the fire protection demand when the two largest units are out of service. Any portion of a water system depending upon a pumping station for continuity and sufficiency of service is particularly dependent upon the pumping equipment at the time of serious fire drafts. The extent to which the safety of the community is centered in the pumping stations is of greater or lesser importance according to whether the system into which the pumped supply discharges is a tight one, or one balanced by a reservoir or standpipe.

A properly designed pumping station for either system of distribution, i.e., "tight or open," will be equipped with units of sufficient size to care for the ordinary consumption demands, with a margin of output capacity to care for at least 50 per cent increase in consumption to meet peak seasonal loads, and to anticipate yearly growth. In addition to this excess capacity, spare units and separate discharge lines will be provided to duplicate entirely the pumping equipment, so as to insure continuous service in the event of a complete breakdown of the units ordinarily operated.

In a pumping station discharging into a tight system, the 50 per cent excess capacity, which conservative design dictates, will or will not include extraordinary fire flow demands, according to

whether or not the total daily output of the station is large or comparatively small and the area and character of fire risk included within the section served by the pumping station are large and hazardous or otherwise. With a normal output of 10 million gallons daily, the 50 per cent excess will allow, under ordinary conditions, 3500 gallons per minute to be used without affecting the domestic service, which may be entirely adequate for some sections, but insufficient for congested manufacturing or warehouse territory. These elements all enter into the question as to what extent provision must be made in the station design to care for fire demands. If these factors indicate that units for fire protection must be added to the station equipment, they must be of a type that can be brought into operation within the minimum time and designed for continuous full load duty, and, of course, installed in duplicate units.

In a balancing reservoir system, the question of pumping units for extraordinary fire flows is of less importance. The factors that determine the need of such equipment are principally those of standpipe or reservoir capacity, and size of mains from the reservoir to the area included within the district considered for fire protection. A well balanced distribution system will include mains sufficiently large to care for extraordinary fire flows, whether the pumping station that supplies the system is operating or not and for this reason the duplication of equipment in the station, plus the 50 per cent excess capacity, will be sufficient for all demands that the station must meet at times of heavy fire drafts.

DISTRIBUTION SYSTEM

The distribution system should be well gridironed and supported by looped feeder mains, any of which may be shut down without causing a reduction in pressure on the system. Particular care should be given to this phase of the problem. Grids should be designed so that the maximum demand may be placed upon them without serious reduction in the static head that theoretically should be maintained.

RESERVOIRS

Balancing reservoirs or standpipes, particularly on the ends of long feeder mains traversing congested sections where demands are high, seem particularly adapted to the maintenance of good pressures without the need of exceedingly large mains in the distribu-

tion grid, for it should be pointed out that the normal consumption can be supported by a distribution grid made up of mains considerably smaller than those required for adequate fire protection and any means of saving pipe cost without increasing friction losses or otherwise causing detriment to the service is desirable. With such reservoirs or standpipes on the ends of feeder mains, storage may be built up during the night periods of low consumption to maintain a uniform pressure during the day periods of high consumption.

Reservoirs are also important when the entire community cannot be supplied by gravity from the water source, but requires more than one zone of distribution. Where the area served is not flat, but steep and the territory to be protected more extensive, sufficient reservoir capacity in the various zones of distribution should be provided to guarantee consumption demands for at least a five-day period and the fire protection demand for a ten-hour period, this provision being made not only to reduce the hazard of excessive drouths, but also of failures of pumping stations. Supply lines from reservoirs should preferably be in duplicate and to secure further duplication of supply it seems advisable to provide a number of smaller reservoirs rather than one larger reservoir whose capacity alone is sufficient. By dividing the required storage among several units greater protection against failure is secured. In flat country, rather than reservoir capacity, greater pumping capacity is required together with a well grid-ironed system of larger feeder mains leading from the pumping stations along arterial highways.

PRESSURE

High pressures are neither desirable nor necessary, especially since the automobile pumper is becoming part of the regular apparatus of all fire departments. It is, therefore, better to provide mains capacity than very high pressure and a pressure averaging 50 to 60 pounds on a well balanced gridiron may be considered adequate and economical as well, although in congested sections where the buildings are high a pressure of seventy-five pounds is desirable.

FIRE HYDRANTS

Having provided a main capacity and pressure, the spacing of fire hydrants is of next importance. Bearing in mind that a discharge of at least six hundred gallons per minute with a friction loss

of not more than 2½ pounds in a hydrant and a total loss of not more than five pounds between the street main and outlet is required adequately to supply the standard automobile pumper, rated at 750 gallons per minute, fire hydrants should be placed upon reasonably short branches and on mains of sufficient size to guarantee this discharge, considering the number of hydrants taken off between points of support. The actual spacing of hydrants, i.e., the determination of the area protected per hydrant—has been established by the National Board of Fire Underwriters and their recommended spacing cannot be improved upon, although it is desirable to recommend further that hydrants be placed at intersections to obtain advantage of the supported gridiron, and spaced systematically and symmetrically to facilitate the work of fire departments.

VALVES

The best designed system is poor practically unless continuity of service can be assured. Failures of water mains are often experienced, especially in congested sections where the fire risk is high. Therefore, valves on the distributing mains should be installed at intervals not exceeding 500 feet in high value districts and 800 feet elsewhere, while on feeder mains this spacing may be increased to ¼ mile. The scheme followed in Baltimore is to place valves every 300 to 500 feet or at every intersection on the minor distributing mains in important districts and at least every 600 to 1000 feet or at alternate intersections in other districts; every 600 to 900 feet on secondary supply mains, and every 900 feet to ¼ mile on the primary feeder mains. The importance of valve spacing is commensurate with that of duplicate supply mains and looped feeder mains.

Therefore, reviewing various points to be considered in the relation of the water supply to fire protection we commence at the point of discharge, or, in other words, at the fire hydrant. The number of fire hydrants may be determined by the quantity of water required for the adequate fire flow. This number dispersed throughout the area to be protected will in turn determine the proper hydrant spacing. With these discharge points established a gridiron may be designed to equalize pressure and discharges sufficient for the demand. It is then simple to determine the required sizes of the secondary and primary feeders back to the reservoir which should

be designed of sufficient capacity to meet the most severe conditions. In this respect one should not lose sight of the advisability of duplicate supply lines and counter-balance reservoirs, providing a supply to the system from opposite directions, nor should the requirements for fire protection be lost sight of in designing the impounding works and conduits which should be of sufficient capacity to maintain normal conditions during a serious conflagration during the drouth period.

MAINTENANCE OF SYSTEM

The perfect system physically must be properly maintained. Systematic maintenance surveys, therefore, such as pitometer surveys for under ground leakage, valve surveys, electrolysis surveys, systematic pipe cleaning, pressure surveys and fire flow test surveys to determine the practical functioning of the system, should be continued without interruption.

EMERGENCY SERVICE

Proper emergency service should be provided at district stations, such as emergency corps and valve operating trucks provided with a fire gong, equipped to handle every type of work, ready at instant call throughout the twenty-four hours.

The establishment of district yards in cities over 500,000 population is desirable for the purpose of providing quick and satisfactory service in emergencies.

PRIVATE FIRE PROTECTION WATER SERVICE

Now that some points, relative to the general water system, have been touched upon, consideration should also be given the private fire protection service. Indeed much more attention than it now receives should be given this subject by the water works engineer, particularly with reference to the design of the interior pipe systems for the probable requirements of mercantile and manufacturing plants. Such requirements should be recognized in the design of the distribution gridiron, and the responsibility of the water works engineer should perhaps also extend to the determination of minimum requirements for the economic design of the private fire protection systems.

A private fire protection line should carry a fixed service charge, although there should be no charge for the water actually used for

the extinguishment of fires. Where a water works is required to stand ready to supply the demands that may be placed upon it by the private fire protection service, it should be compensated for this readiness to serve by the owner of the building benefited. The general adoption of such a charge for private fire protection lines might lead to the reduction in the number of sprinkler connections and to a reduction in the sizes of such services requested, but this would not be warranted.

The size of the private fire protection service granted should never equal that of the water main from which it is taken. The city main should always be large enough to more than supply the service required from it.

The secondary supply is necessary for reason of the sprinkler system, whose purpose is to extinguish fires in the incipient stage. Therefore, the supply to such systems should be fool-proof and absolutely reliable. The sprinkler system is to control the fire, when it begins and is not for the purpose of combating a serious conflagration, resulting from an exposure by an adjacent building which is burning. Therefore, for sprinklers alone, the elevated tank of sufficient capacity to supply the required number of sprinkler heads for twenty minutes at the rate of 25 gallons a minute a head, is more desirable than a large private fire protection line, as there is danger in the case of the large fire protection line bleeding the system main, if it should be broken. On the other hand, where it is required to supply a yard fire hydrant system, a large private fire protection service is sometimes important.

For the purpose of study, some consideration might also be given the use of the automatic control valves on the private fire protection service to guard against bleeding of the system in the case of the service being broken by falling walls. Such automatically closing valves, however, may be unnecessary in cities providing an emergency corps of the water department who respond to all serious fires. In this case there is probably no need of the automatic device, as the valve on the service line could be closed by the employees of the water department.

One other topic is important, that is, the means that should be adopted to prevent the pollution of a public water supply through an independent private fire protection system, which may be connected to the private fire protection service from the public supply.

It is not desirable to have any mechanical connection between the

private supply, which is usually raw polluted water and the public water supply, even though such connections may be protected by more than a single check valve or positive acting gate valve, for there are many cases on record where the public water system has been polluted through such connections. Where it is desirable to have an augmented fire protection service, one supplied by the public mains and a private source as well, the public supply line should be made to discharge into an elevated tank above the water surface, with this tank supplying the private fire protection system.

HIGH PRESSURE WATER SYSTEMS FOR FIRE PROTECTION

Much thought has lately been given to high pressure water supply systems. In small cities where there are no tall buildings the economy of a separate high pressure system is doubtful, for it seems, after the experience of later years, that adequate protection for such communities could in all probability be given by the properly designed general distribution system. The advantages of a high pressure water supply system for fire protection may be secured economically where large supply mains, reservoirs, rivers or harbors are convenient to provide suction for high pressure system pumps, or where there is storage capacity provided on an abandoned water supply. However, where such supplies are available and could be brought by gravity to the high pressure pumping station in that section of the city to be protected, it would be advisable to construct a distinct high pressure system for the utilization of such an untreated water supply. The maintenance of such a system utilized where there are tall buildings to protect would not be so expensive as to prohibit it. Any high pressure water supply system for fire protection should be for the exclusive use of the fire department and no private fire protection supplies should be connected to it.

ZONING

The real problem is the determination of the future requirements of the community to be supplied, for at this time economics is given the consideration it deserves in the design of the water systems by water works engineers. It is almost impossible for the engineer to anticipate the development of a community.

The use, height and size of buildings as well as population density all determine to some degree the amount of service a water department is called upon to furnish. Domestic supply and fire supply

requirements are both directly affected by the occupancy of the buildings. These requirements further fix the size of water mains and affect pumping stations.

An area zoned for two and three story building, with mains laid to provide for domestic and fire protection supplies, may by transformation into another use disarrange the entire network of pipes. The height of buildings affects water service in two ways, by concentrating persons and industries in a given ground area and by making such demands for pressure as to require additional connections or appliances. The concentration of population and of commercial or industrial use is self-evident, and increases in direct ratio with the height.

While the use of buildings determines the amount of water service to the extent of possibly 90 per cent, the effect of the height of buildings is variable depending upon the use or occupancy as well as upon the degree of responsibility assumed by the water department in furnishing water at desired pressures inside of the buildings.

The size or bulk of a building directly affects the service that is required to the extent of possibly 5 per cent. A building covering 100,000 square feet of floor space may be protected by a sprinkler system supplied by an 8-inch service pipe. A building covering 25,000 square feet could be served from a 4-inch supply. The 8-inch sprinkler line would be taken from at least a 10-inch main, while the 4-inch supply might be taken from a 6-inch main in the gridiron.

The concentration of activities in one large building results in the concentration of the water use from one supply line, which may materially change the main sizes in the gridiron serving the vicinity. Population density directly affects the total amounts of water required for any specific use. Examples from the experience of any city would illustrate these points.

Therefore, it is most important that the community be zoned in order that its development may be regulated by governmental process. Zoning provides for the engineer not only a clearly defined picture of the nature of the demand which will be made upon the water supply, but defines this picture by giving such details as the height and bulk of buildings, the area of clear spaces and highways which become factors in estimating the probable future fire flow requirement, for the required fire flow is the maximum demand that will be placed upon the water supply. It is true that the

effect of zoning cannot be felt immediately in a city already established, but although its ideal is not at once realized, the ultimate effect of this regulation on the growth of a community gives reliable aid to the engineer in closely approximating the development trend from field observations. This relationship between zoning and water supply should be clearly established in the minds of water works engineers and in the minds of municipal officials. This has already been pointed out by a member of this Association, H. Malcolm Pirnie, in a recent paper before the American Society of Civil Engineers on this subject:

> Stability in existing water works structures and in present provisions for the future water supply of a community is dependent on stability in building, and may be secured by the early adoption of a carefully prepared zoning plan and ordinance.
>
> In preparing a zoning plan, the water supply must be given due weight with all other purposes in view. Water has been and still is about the cheapest of all public necessities. Its cost in the future, however, will be greatly increased in some communities, if the city plans are made without consulting the water authorities. It is possible even to destroy an existing source of water supply by disregarding this phase of the problem, thus burdening the city with a cost for new works out of proportion to the benefits resulting from zoning.

ASSOCIATIONS

Finally, the water works engineer should endeavor to secure the coöperation of the chief of the fire department in his community and there should be a more liberal understanding between the water works officials and the Fire Underwriters Associations. The writer has already received hearty coöperation from both the engineers of the National Board of Fire Underwriters, the local Associations and the Chief of the Fire Department, and a similar understanding and liberality would be generally beneficial to all concerned.

DISCUSSION

L. K. SHERMAN:[3] Mr. Siems brought up a very important point in the last part of his paper, viz., the use of fire engines versus fire pressure at the pump station. His paper also brings up the relation between the Underwriters' requirements and the engineer's program that can be carried out, bearing in mind the financial and practical situation of the municipality. I have in mind the case of the small

[3] President, Randolph-Perkins Co., Chicago, Ill.

city, one with a population between 1500 and 5000. In one particular instance in a little city of 1800, the Underwriters Bureau called for the installation of both automobile pumper and pressure of 80 pounds per square inch at the fire pump in the water works. In cases like this it seems to me that these two requirements of the Underwriters are excessive and at variance with the conclusions that Mr. Siems presented which, you recall, were that a single normal pressure of 50 or 60 pounds at the water works together with an automobile pumper was sufficient. I would like to get the opinions of this Association. In the case of a town of 1800, is it necessary to have both a pressure at the water works of 80 pounds for fire, together with an automobile pumper? If that is not necessary, which is better, the low pressure of 50 or 60 pounds with pumper or the high pressure of 80 pounds without a pumper? In my opinion 80 pounds pressure in the mains is an excessive requirement if an auto pumper is used.

H. A. DILL:[4] While not answering that question directly, I am considerably interested in it, representing a plant in the city of 30,000 population, and I believe there are others here who are in a similar situation. This matter of extra fire pressures has become quite a serious one with us. Before going under the Public Service Commission we were under contract with the city, and were required for about half the fire alarm boxes to raise the pressure to 110 pounds on any hydrant on the first alarm. Since going under the Commission, that has not been modified. In one year on twenty-three out of twenty-five box alarms, by admission of the Chief, there were only two calls where extra pressure was necessary. We have a reservoir giving a pressure in the central part of the city of 70 pounds. Last fall, with one pumper on a long 8-inch dead end main, there were five fire streams, two from a hydrant and three drawing from a pumper. The gauge at the office registered 140 pounds; after about five hours pumping, something happened. A section was blown out of one of the 20-inch mains, 7 feet long and 18 inches wide. A good deal of information has been secured from Indiana cities about what they are doing for raising fire pressures, but so far the consent of the Chief of the Fire Department has not been obtained to alter the present rule. Maybe we have not worked the coöperation plan sufficiently that Mr. O'Brien spoke about yesterday. While the

[4] Superintendent, Water Works, Richmond, Ind.

National Board of Fire Underwriters do not advocate extra pressure, they do not come out strongly against it. With two fire pumpers and with normal pressures from forty to one hundred pounds, and assuming that the volume is furnished in any district, it seems to me that it is unwise and dangerous for a city to require a company to give excess pressures subjecting the entire system to a breakdown.

W. S. CRAMER:[5] A recent survey at Lexington brought out what may be interesting to Mr. Dill as to what the Underwriters will require. We have four pumpers, I believe, with a combined capacity of twelve streams. In answer to an application for a reduction of rates, they required three additional pumpers of three streams capacity each, making, I think, 21 stream requirements from the pumpers before they would agree to relinquish the city contract for a raise of pressure in case of fire. We have 90 pounds on the first call and 110 on the second. That is about what their requirements are in a city of 45,000 inhabitants. They are in favor of it, but make pretty strong requirements in the way of pumpers and the number of streams you have to furnish.

CHAIRMAN HILL:[6] Are there any further remarks? I think possibly a little something may be said that may help a bit in connection with the question that has been put up by Mr. Sherman. The question of static pressure depends to a great extent upon the system of mains in the distribution system and the friction losses from the point of supply to the point of discharge. If a town has a well designed system with large mains and low friction losses so that the residual pressures when the pumper is being used is adequate at the hydrant, they may operate with lower pressures than the town which is not so designed, that is, with lower pressures at the pumping station. Our own experience with the Underwriters is that they are not so much interested in static pressure at the pumping station as they are in the residual pressure at the hydrant, when the hydrants are being drawn upon for fire protection, and unless the condition is very unusual in the town mentioned, I am surprised that they should ask for any such pressures, because, in my experience they have not done so where pumpers are used. In fact, in the east I know that the National Board of Underwriters asked a residual

[5] Chief Engineer, Water Company, Lexington, Ky.
[6] Consulting Engineer, New York, N. Y.

pressure at the hydrant when the hydrant is being drawn upon for a given quantity of water of from ten to twenty pounds. Now, of course, if it requires 80 pounds at the pumping station to give 10 or 20 pounds at the hydrant, that may explain the reason. On the other hand, if it only requires 40 pounds at the pumping station to give 10 pounds or 20 pounds residual at the hydrant, that is all that should be required where pumpers are used; in other words, there is a relationship between pressure at the pumping station and the size of the mains in the grid which deliver the water to a given point for fire protection, and I do not know whether that question could be answered definitely unless the conditions were more fully stated; but generally speaking, it seems to me absurd to require the cost of heavy plumbing and the additional cost of repairs to plumbing and the extra cost in the way of cast iron mains to withstand heavy pressure, to say nothing of the danger of the distribution system giving way at the very time they do not want an accident of that kind, by maintaining excess pressure on the system. I know from my own experience that in many towns where they raise the pressure at the pumping station, there is always a flood of requests on the plumbers to come and repair the plumbing after the pressure has been raised for fire protection purposes.

L. K. SHERMAN:[3] I do not want to give the impression that the National Board of Fire Underwriters requires these pressures; it is the city. Tests by the Board three years ago showed that there was no place where there was a residual pressure of less than 15 or 20 pounds.

W. W. BRUSH:[7] In reference to Mr. Siems' paper, there was one point I wanted to bring out to you, and that is whether one is adequately safeguarding the continuity of the supply by a duplicate delivery main system from a pumping station. I have seen, in connection with my own works, a plan brought to me where there is one valve separating the two delivery mains. Now if that valve gives way your station is done. It is very correct to say that that valve is not likely to give way, but I personally would advocate putting in two valves between a duplicate system of delivery mains. It is something which we may overlook, and yet, if the valve gives

[7] Deputy Chief Engineer, Department Water Supply, Gas and Electricity, New York, N. Y.

way, we are very sorry we have overlooked it, and the cost of the additional valve is a small expense compared with the expense we incur to duplicate the main. Secondly, I think we should all examine our systems from a point of view of seeing whether we have an adequate duplication. We have been inclined in the past to be very economical in our water supply systems. The reaction of the individual toward the cost of water is rather surprising to me, indicating that he is rather concerned about the cost of water when the cost of water is practically negligible in the budget of the family. The head of the family pays on an average of perhaps $1.50 or $2.00 a year for water per person in his family. Now, if that were doubled, it would not make any difference virtually in the amount of amusement he would be able to get or the amount of clothes or food or any other item in his family budget and by adding to the cost of the water far less than doubling the present cost, you can put your system in such a condition that there is no question about the adequacy of the various parts to function even though some one part gives way.

In New York, within the last two months, we have had a case where in spite of quite extensive appropriations to avoid leaving a rather large section, several blocks in area, without water, we did leave those areas without water due to a lack of duplication of mains for which there were various reasons, but it should not have been so, and I trust that it never again will occur. I do not believe after two years from now that it ever will occur again in New York City. That should not happen, unless you had a catastrophe which might result from an extensive earthquake or something of that character which none of us could prevent; but, nevertheless, as Mr. Fenkell suggested, it would be advisable to see that we are fairly well equipped to handle a situation that might come as the result of an earthquake and we should not hesitate to put up to our financial authorities the question of spending the money to duplicate part of the system.

I hope you will pardon me if I refer simply to New York, because I know that system and do not know the others very well. In New York we have the question of being dependent upon a single aqueduct for the supply that represents now two-thirds of our consumption. It will cost us $40,000,000 to duplicate that aqueduct in round figures. I do not think the city of New York should hesitate for a minute on spending that $40,000,000 to duplicate that aqueduct.

It means that it will add to the family budget thirty cents a year for each person to safeguard two-thirds of the present supply of New York City. Now we have people of various nationalities, various races, in our city; some might hesitate on that thirty cents, but I do not think that, as water works engineers, operators, and superintendents, we would be doing our duty, if we failed earnestly to advocate the spending of that thirty cents per person to safeguard the supply, and what applies to New York applies to every other community. We happen to be the biggest aggregation of people, but that does not change our problem. Whether we be six million people or 30,000 or 10,000, we ought to see to it, that, as far as can be, we safeguard the continuity of our supply.

As to what we do in practice on the question of our fire service, we have, on second alarm fires, a gang that responds, and that gang is kept on duty throughout the twenty-four hours. That is true of our larger boroughs, Manhattan and Brooklyn; it is not true of the outlying boroughs. The gang responds to two-alarm fires, and they are there to do anything that would be helpful to the fire department. They are very seldom called upon to do anything, but they take a record of the pressures at all the engines, and if anything should happen that would affect the water supply, they are there to take immediate action and aid the fire department. Our fire department thinks that is necessary; I do not know that it is necessary, but it is what we do.

We do not give our hydrants nearly the care that some of you men give in smaller communities, but we do try to have them all examined at least once a year. We have our gangs so that our hydrant repairs are absolutely within about three days of up-to-date. Some two years age we were way behind, but we now have these special gangs that look after the hydrants and I think it is easy to be within three days of up-to-date on your hydrant repairs.

Mr. Hill has just spoken about the question of emergency service. That necessarily will have to be based upon the size of the community and the conditions. In the borough of Manhattan, what I have been advocating for several years, but have not as yet succeeded in having allowed, is to have an assistant engineer on duty throughout the twenty-four hours every day in the year, whose function and duty would be to be in the office, see that the maps of the distribution system were kept up to date by working on them during his hours that he is not on outside work and only go outside when he is

called on account of emergency, and then he would have a machine that would be available at headquarters and he could reach any part of the city in a very short time, probably half an hour at the most. He would then take care of shut-downs. What we do is to have our engineers on emergency duty so that from the time they reach home until they arrive at the office, there is some man who must be within telephone call, and the list is given to the various men, so that they can reach that man, but in a case of a large community like New York, where we have our subways and the interference and damage caused by breaks in the mains, I think there should be somebody who can reach the job within the time necessary for an automobile to travel from headquarters to the place of the break, and take charge and act intelligently. You have a good many valves to operate and your foremen, while pretty good, frequently fail to appreciate the situation that confronts them and do not take action that would be as satisfactory as that taken under the direction of a trained engineer. That engineer would have to rotate with the other engineers so that he would not be on that duty continuously, for you would not get men worth while to stay on that work, if they did not think there was any future for them. We have these gangs at night in all the boroughs, so that they are there and they have no other function than to respond to emergency calls. If a gang goes out on an emergency call in the large boroughs, we try to have another gang available while it is out in case a second call comes in.

D. R. GWINN:[8] I agree with Mr. Brush in regard to the duplication of valves on the main feeder lines. I would go a little further. We have a duplicate system of steam pipe running to the various pipes and extra valves put on them, so that if one goes wrong we have another to fall back on. It is a poor thing for a fiddler to try to play on one string; it is good to have several strings to your bow; that is the plan we have gone on in our coöperation with the fire department. In 1910, when the Underwriters came to our city and gave us some excellent ideas, after they went away we made a tracing of our water system showing all the valves, hydrants and the size of the mains graphically, different lines according to different sizes, and every year we check up that map and make blueprints for every fire house in the city, and they put them up on the wall.

[8] Terre Haute, Ind.

If we add to them during the year, we notify them. If we put in additional hydrants, we advise them, so they can keep in touch with it and know what size the mains are and where the hydrants are located, and the chief looks over them. Then we have a cut-away hydrant showing the operation of the hydrant and we haul that around to the different fire houses and have the chief show the men how it operates, which way to turn it, and what is the actual result of the turning of that hydrant wrench. The consequence was that we got along very nicely with the fire department and cut our fire losses down very materially. Those are things we did years ago, but in later years, it was my pleasure to sit at the feet of our President, Mr. Jordan, who in my mind, has done more to bring about cordial relations between water works superintendents and chiefs of fire departments than any one man in the United States. He is still doing that work, going up and down the country giving his talks on fire prevention and how to do it. He came to our city as the guest of the Chamber of Commerce and gave us a talk on the subject of how to prevent fires, and then we had Chief O'Brien come over and talk, and we had the captain of the Salvage Corps make a talk to the public schools on that line, and the result was at the suggestion of our President we took some action on Fire Prevention Week and ran a regular campaign. We had four minute speakers at the theatres, perhaps also at some of the churches and the schoolhouses. The chief would run out a truck of the fire department and they would sound the fire alarm and get the children all outside, and then one of the firemen would make a talk. We tried first having a lawyer make the talk, but that was not as effective as a man with a uniform; the children pay more attention to a man in uniform than to one in everyday clothes, and the result was that we got the children interested; and then we had 14,000 or 16,000 questionnaires printed about what is the condition of the flues at your house, where do you throw your ashes, and that sort of thing. We made out a long list of questions on letter paper size, and every child was furnished with those questions, in the public and parochial schools, and told to take them home and fill them out and bring them back next day. The result was that the children got good ideas about what to do and they were good workers for fire prevention. Then we offered prizes for the best reports made, and we went to our manufacturers and they offered prizes.

PROPOSED SECONDARY CHLORINATION OF NEW YORK WATER SUPPLY AFTER LEAVING OPEN RESERVOIR AT HILLVIEW[1]

By William W. Brush[2]

GENERAL

The surface water supplies of the City of New York are mainly obtained from the Catskill and Croton watersheds. The existing protection from pollution of these waters is secured by watershed patrolmen, by the city ownership of a small portion of the land bordering on the streams and by the city owership of all lands bordering on the various reservoirs. The waters are used by bathers in the streams and lakes not owned by the city and there is a population of about 25,000 people on the 375 square miles of the Croton shed and a winter population of 13,900 and a summer population of 35,500 on the 571 square miles of the Catskill shed. The purification of the waters is secured by chlorination of part of the water before it enters the main storage reservoirs, by long sedimentation in the storage reservoirs, usually represented by several weeks detention, and by chlorination after leaving the main storage reservoirs.

On the Croton watershed there are five small chlorinating plants continuously treating the flow of minor tributary streams whose waters show evidence of pollution. In addition all the Croton supply is treated at Dunwoodie as it flows through the aqueducts. Dunwoodie is located about two miles above the City line. As the Old Croton aqueduct is built in rock tunnel in Manhattan under Amsterdam Avenue between 135th Street and 140th Street and as the sewers are above the hydraulic gradient in the greater part of this section, it has been considered advisable to again chlorinate the Old Croton aqueduct flow as it enters the gatehouse at 135th Street and Amsterdam Avenue and this has been done since 1924. Numerous tests made of the seepage into this tunnel section and of the flow after

[1] Presented before the Louisville Convention, April 30, 1925.

[2] Deputy Chief Engineer, Department of Water Supply, Gas and Electricity, City of New York.

passing through the tunnel have shown no evidence of pollution in the bacterial content, but the menace of possible sewage pollution is ever present.

The proposal to subject all the Catskill supply to secondary treatment is the one that is considered the most interesting and desirable for discussion so that no further mention will be made of the Croton treatment.

SANITARY CONDITIONS ON THE CATSKILL WATERSHEDS

There are two main watersheds on the Catskill system known as the Esopus and Schoharie. The latter has been available only since the eighteen-mile Shandaken tunnel was completed in February 1924 and now delivers about one-third of the Catskill supply. At the end of 1925 with the completion of the Gilboa Reservoir the Schoharie will deliver one-half of the supply. There are five villages, each with several thousand inhabitants in the summer season, which are to be sewered at the expense of the city, but these systems have not been installed. The watershed is generally used as a summer vacation area and many bathe in the small ponds along the streams tributary to the reservoir. The individual toilets and the sanitary conditions on the farms have been looked after by the city. The water is not now as free from pollution as it will be in a yaer or two hence, when the sewer systems have been installed. The average bacterial and B. coli content of the Schoharie water as delivered into the Esopus stream during 1924 has been as follows: bacteria, 550 per cubic centimeter; B. coli per 10 cc., 201.

On the Esopus watershed the city has constructed one sewage collection and disposal system and plans to construct three more which will adequately care for the communities on this watershed which are smaller than those on the Schoharie shed. The bathing and summer visitor situations are similar to those on the Schoharie shed. The average bacteria and B. coli content of the Esopus water during 1923 before the Schoharie water was added was as follows: bacteria, per cubic centimeter 34; B. coli per 10 cc., 5.

CHLORINATION PLANTS ON THE CATSKILL SYSTEM

a. Boiceville. This plant is located on the Esopus Creek just above the upper end of the Ashokan reservoir and prior to the utilization of the Ashokan reservoir plant in January, 1925, was

operated continuously, except when flood flows were in excess of its capacity of about 1000 m.g.d. This plant is to be used hereafter during the summer season to counteract the bathing and summer vacationist pollution and will treat both the Esopus and Schoharie waters.

b. Ashokan reservoir. This plant is located in the screen chamber at the head of the aqueduct and was placed in service on January 5, 1925. Its function is to treat all the Catskill water to counteract any pollution of the water. Due to the usual long period of sedimentation in the reservoir and the division of the reservoir into two basins the water is generally in a very uniform condition and low in bacteria, including B. coli, but at times of heavy flood flows the water may have a relatively high turbidity and reach the outlet chamber in a couple of days after entering the reservoir. When the construction of sewers on the watersheds has been completed it may be deemed advisable to operate this plant only when the water is polluted by flood flows, but this question is one for determination in the future.

During 1924 the average condition of the water as delivered into the aqueduct was: bacteria, 84 per cubic centimeter; B. coli per 10 cc., 0.45; turbidity 5. Its condition as drawn at time of high turbidity was; bacteria, 152 per cubic centimeter; B. coli per 10 cc., 0; turbidity 16.

c. Kensico Reservoir. The plant at the screen chamber on the aqueduct below the effluent chamber of Kensico reservoir is the main plant and has been designed to maintain constant delivery of chlorine into the supply. For a very few hours each year there have been interruptions in the flow of chlorine, but the prior purification of the water has been so consistently high that such interruptions have not been considered serious. Kensico reservoir has a tributary watershed of 22 square miles and a flow from the Ashokan reservoir of about 600 m.g.d. The tributary watershed is rather sparsely settled and the pollution reaching the water is limited to surface wash. Since the Catskill aqueduct was completed to its full capacity in December, 1924, the flow into the reservoir has increased 50 per cent, reducing the average time of the water passing from the influent chamber to the effluent chamber a distance of three miles from about three weeks to two weeks. The Kensico reservoir has an available content of 30,000 m.g., but a large portion of this water is stored in the reservoir outside of the line of flow from the influent to the effluent chamber.

The average condition during 1924 of the raw water from Kensico reservoir and the treated water was:

Raw water: Bacteria, 25 per cubic centimeter; B. coli, per 10 cc. 0.12
Treated water: Bacteria, 8 per cubic centimeter; B. coli per 10 cc. .0.005

The turbidity of the Kensico reservoir is usually two to three parts per million on the silica scale, and the maximum turbidity was five in 1924.

CONDITIONS TO BE MET BY THE HILLVIEW RESERVOIR CHLORINATING PLANT

After the water passes the Kensico chlorination plant it flows through fourteen miles of aqueduct consisting of concrete cut and cover, concrete lined grade tunnel, concrete lined pressure tunnel and steel pipe siphon types of construction. The hydraulic gradient is below the ground water level for various portions of this distance and possibility of pollution exists, although at present it is very slight. Hillview reservoir is an open basin with a dividing wall usually below the water surface and through which a bypasss conduit is constructed which can carry about two-thirds of the present demand. From the end of August until the following April sea gulls flock to this reservoir at times numbering thousands. They alight on the water arriving about eight o'clock and remaining until dusk. If an air plane passes over the reservoir they will disappear for the remainder of the day. Under the New York State Laws they cannot be killed and the legislature has refused to modify the law to permit these birds being killed if found on a distribution reservoir. For the greater part of the time from one to two men are kept out on the surface of the reservoir in a boat to shoot at the birds in such a manner as to have the shot hit the water but not hit a gull. Experience over several years has shown that the birds soon lose their fear of the men and cannot be driven away in this manner unless more boats be used. The effect of the gulls on the pollution of the supply is evident in the late summer and fall as shown by the average B. coli content during this season and the season when the gulls are not present. In the cold weather the effect of the gulls is not noticeable in the B. coli content. The water after treatment at Kensico as shown by daily tests, was free from B. coli in 10 cc. during the entire twelve months with the exception of one sample and was also virtually free from B. coli in 100 cc.

DATE	B. COLI CONTENT IN 10 CC. AFTER THE WATER LEFT HILLVIEW RESERVOIR
Prior to August, 1924	0
August, 1924	0.10
September, 1924	1.73
October, 1924	0.80
November, 1924	0.02
December, 1924	0

This result was shown in spite of the by-passing of the reservoir during September and October to the extent that the capacity of the by-pass permitted.

The Hillview reservoir is surrounded by a wire mesh fence 6 feet high of the non-climable type and set back about 20 feet from the water line. The State Department Health officials have suggested that the water might be contaminated by throwing something over the fence either with deliberate intention or due to ignorance. There are very few visitors to the reservoir grounds and the chance of such pollution seems very slight.

Microscopic organisms, especially synura, have developed in the Kensico reservoir without being detected by the daily laboratory examination before a distinct taste has been imparted to the water by the chlorine destroying these organisms. The synurae have been controlled up to about 100 units per cubic centimeter by excess chlorination, copper sulphate treatment being resorted to as soon as possible after the synura organisms have been noticed.

REASONS FOR PROPOSING TO OPERATE BOTH THE KENSICO AND PROPOSED HILLVIEW CHLORINATING PLANTS

When the Hillview plant is installed, which it is expected will be during 1925, we propose to operate both plants for the following reasons:

a. The Kensico plant will give warning of the presence of synurae in sufficient numbers to cause taste before the laboratory might notice them. This taste when first noticed generally disappears during the six hours required for the water to flow to Hillview and by increasing the chlorine dose at Kensico the taste is removed pending the destruction of the synurae by copper sulphate treatment. Without the treatment at Kensico the taste created by chlorination at

Hillview when synurae are present would not be dissipated before the water reached the consumer, which for some sections of the city would be within an hour.

b. Secondary chlorination at Hillview virtually removes any chance of any particle of water reaching the consumer without being treated.

c. Hillview reservoir effluent chlorination will counteract the gull pollution and any accidental or intentional pollution of the water while in Hillview reservoir. After the water leaves the reservoir it is under a pressure which exceeds the outside ground water pressure at all points thus preventing any subsequent pollution.

d. The chlorine dose at Hillview can be maintained at a lower rate if it follows a previous chlorination about 12 to 24 hours earlier at Kensico and thus minimize the danger of any excess chlorine taste due to difficulty in control of amount of chlorine with the daily and hourly fluctuations of the draft from Hillview reservoir to meet the consumption demand.

e. Elimination of any reasonable basis for any suspicion of the sanitary quality of the Catskill water as delivered, if any unusual rise in the typhoid fever rate developed such as was traced to oyster pollution during the past winter.

CONCLUSION

The dependence on chlorination for the safety of a water supply demands a higher degree of insurance of adequate and absolutely continuous treatment of the water than has been the general practice to date. The use of the excess chlorine control method has been a great aid in determining the safe minimum dose, but more attention should be paid to the possibility of drops of water passing the treatment plant either untreated or insufficiently treated. Turbidity means that bacteria may be encased in matter in suspension which is not broken up or penetrated by the chlorine. The delivery of the chlorine is not uniform enough and is not distributed generally in a thorough enough manner to insure at all times sterilization of the entire mass of water treated. Secondary pollution in open reservoirs or in conduits with gradients below the water level in the surrounding soil may occur and must be counteracted by secondary treatment.

This subject is a most important one and is deserving of consideration and discussion with a view to placing the chlorination of water supplies on a safer and more logical basis than exists today.

PRICE TRENDS UPON CENTRIFUGAL PUMPS

By Leonard Metcalf[1]

The following data concerning price trends of centrifugal pumps, prepared by one of the large manufacturers of pumps in this country, was unfortunately received too late for inclusion in the Manual of Water Works Practice, recently published by the American Water Works Association.

In order that the data may be available to those interested in price trends and in the valuation of water works, and may be added to Table 32, page 489 on "Price Trends of Labor Construction, Materials and Supplies of Water Works in the United States" of the Manual, they are presented below.

The first group covers the fluctuation of prices for various types of single stage centrifugal pumps of less than 125 horse power for motor drive, including the bed plate and coupling. The cost of the electrical equipment has been excluded, as it would cover a considerable range, depending upon the type of current, voltage, starting equipment, etc.

The second group covers the fluctuation in prices of single stage centrifugal pumps of more than 125 horse power for motor drive, including bed plate and coupling and excluding electrical equipment.

The third and most significant group covers the fluctuation of prices for turbine-driven units of large size.

The fourth group covers the fluctuation in prices for small turbine-driven multi-stage centrifugal pumps.

It will be noted that the present day price upon the first group (small motor driven units) of less than 125 horse power, is very little above the pre-war price. This is accounted for largely by the fact that the pump casings are now being manufactured in quantity. On the other hand, the prices on motor driven pumps of larger capacity than 125 horse power have risen more in accord with the general increase in cost of labor and materials, since these pumps cannot be put through the shop in quantity lots.

[1] Consulting Engineer, of Metcalf and Eddy, Boston, Mass.

In the large turbine-driven units, it is difficult to get strictly comparable data, because the costs vary widely with different types of casing, gear and pump bleeder arrangements, steam conditions, governing devices, etc. The figures submitted cover various actual installations based usually on the use of a multi-stage turbine and two pumps in series, the figures compared being the actual final contract prices.

Year	PRICE TRENDS UPON			
	Motor driven centrifugal pumps of less than 125 h.p.*	Motor driven centrifugal pumps of more than 125 h.p.*	Large steam turbine driven 2-stage series centrifugal pumps, complete.†	Small steam turbine driven multi-stage centrifugal pumps, complete.
(1)	(2)	(3)	(4)	(5)
1909		90		
1910	90	92		
1911	92	94		
1912	94	95		
1913	97	98		
1914	100	100	100	
1915	107	113	85	100
1916	114	126	137	140
1917	122	136	166	195
1918	130	146	186	220
1919	142	158	188	244
1920	154	170	189	260
1921	156	162	191	244
1922	130	155	192	240
1923	112	148	192	234
1924	110	146	193	230
1925	110	145	194	225
10 years (1915–1924)	139	146	172	211
5 years (1920–1924)	124	156	191	242

* Including bed plate and coupling, excluding electrical equipment.
† Most significant and characteristic group.

In general, it would probably be safe to say that the large turbine-driven pumping units have doubled in cost since 1914, whereas the average cost of the motor driven pumps of the larger sizes has increased about 50 per cent and of the smaller size about 20 per cent. The greater increase in cost of the turbine-driven units is, of course, accounted for by the fact that they are designed and built to meet special conditions, and because of the refinements that have been made during this period, involving higher steam temperatures and duty, etc.

From the point of view of valuation, the third group of figures given, covering the fairly large turbine-driven units, is the most significant because the costs involved therein are far greater than those involved in the small units and are on the whole more characteristic of the entire pumping plant.

STUDIES OF DIFFERENTIAL MEDIA FOR DETECTION OF BACT. COLI IN WATER

By H. G. Dunham, M. H. McCrady and H. E. Jordan

One phase of the work of Standardization Council Committee No. 1 (Standard Methods of Water Analysis) has enlisted the coöperation of a large group of workers over the country, and has reached the stage that a definite statement of the progress made to date should be available for general study and criticism.

This work has been done under the supervision of Jack J. Hinman, Chairman of the Committee, with sub-topics directed by the authors. The study is based upon what appears to be a need for revision of the present standard A. P. H. A. method for determining the presence of the colon group of lactose fermenting aerobes.

I. DYES FOR CULTURE MEDIA

BY H. G. DUNHAM[1]

Coincident with the cutting off of the former supply of Gruebler dyes, and later with the importation of post-war Gruebler dyes and the availability of American-made dyes, came the uncertainty of results obtained. Most workers necessarily had to use the new sources of supply, preferably the American-made dyes. The results with these new dyes were not always satisfactory from a cultural standpoint, and in a great many cases we were not fortunate enough to have, for comparative studies, the old pre-war dyes on which our formulae were based.

Realizing this uncertainty and the great importance of the proper concentration of the right dyes in certain culture media, a section of Committee No. 1 was assigned to the duty of studying the available dyes for use in eosin-methylene blue agar, brilliant green bile medium, and gentian violet lactose broth.

To simplify matters we secured dyes from American manufacturers only. A list of American dye manufacturers was made quite com-

[1] Director, Bacteriological Laboratory, Digestive Ferments Co., Detroit, Mich.

plete with the kind aid of Dr. H. J. Conn, Chairman of the Commission on Standardization of Biological Stains. Samples of dyes were obtained from: National Aniline and Chemical Company, The Harmer Laboratories Company, Empire Biochemical Company, Hartman-Leddon Company, Providence Chemical Laboratories, The Heller and Merz Company, Dye Stuffs Laboratory Company, Albert David Chemical Company, Calco Chemical Company and E. I. du Pont de Nemours and Company, Inc.

Eosin Y and methylene blue

The logical way to study the dyes for this medium seemed to be to compare each eosin with each methylene blue. Such a project was impossible, so Dr. Levine (proponent of the formula) compared all of the eosins with his original pre-war Gruebler methylene blue and also with methylene blue No. 4 manufactured by the National Aniline and Chemical Company (this particular lot had previously been examined and found quite satisfactory). From Dr. Levine's work eosin No. 28, manufactured by the Dye Stuffs Laboratory Company, was selected as one of the most satisfactory eosins when used with methylene blue No. 4.

A method was drawn up to compare each eosin with methylene blue No. 4 and each methylene blue with eosin No. 28. A basic dehydrated medium containing all the ingredients except the dyes, and a sample of each of the eleven methylene blues and eight eosins were submitted to each of the eight workers who very kindly coöperated in this problem. The 19 combinations of dyes were compared with each other, paying special attention to *vigor of growth*, *sheen*, and *differentiation*. Cultures of Bact. coli and Bact. aerogenes were used to determine these points.

Taking into consideration all of these points, we were able to select five combinations that seemed to produce the most characteristic reactions. Most of the remaining combinations were poor in one or more characteristics.

Brilliant green

The work on brilliant green consisted, essentially, of a comparative study of the effect of added dye, in varying concentrations, upon the metabolic activity of laboratory strains of Bact. coli, Bact. aerogenes, and B. welchii. Gas production was taken as an indicator of met-

abolic activity, and was recorded after twenty-four, forty-eight and seventy-two hours incubation. The dye medium in each case was compared with the same medium without the dye. All workers were supplied with a method, a dehydrated basic medium, and 9 different samples of dyes. The relative amount of gas produced in the dye medium in comparison with the same medium without the dye was determined by dividing the amount of gas in the dye medium tube by the amount of gas developed in the control tube.

As a further check on the effect of the dyes, a study was carried out to determine the dilution of rejuvenated culture necessary to insure growth in 1/10,000 brilliant green bile medium in comparison with lactose broth containing ingredients in proportions given in "Standard Methods" 1923, published by the American Public Health Association.

From these studies two dyes were selected that were very satisfactory, and four others were considered practically as good.

Gentian violet

The studies of gentian violet were essentially the same as those carried on with brilliant green, except that the basic medium was lactose broth containing ingredients in proportions given in "Standard Methods" 1923.

For this study we were fortunate in obtaining two samples of prewar Gruebler gentian violet from Jack J. Hinman, Jr., and Max Levine. These two dyes were compared with one of the American-made dyes by M. S. Marshall of the Bureau of Laboratories, Michigan Department of Health.

The work on gentian violet does not warrant any definite conclusions. It is hoped that more work can be carried on during the present year to determine, if possible, the best available gentian violets.

Conclusion

It is hoped that this preliminary report will encourage further work and stimulate greater interest in the dye media problems. It is further hoped that the American dye manufacturers will be supported in their attempts to supply laboratory workers with better dyes.

This work was made possible by the kind coöperation of:

M. S. Marshall, Bureau of Laboratories, Michigan Department of Health, Lansing, Mich.—Coöperating on all three problems.
J. W. Kellogg, State Laboratory of Hygiene, Raleigh, N. C.—Coöperating on eosin methylene blue agar and brilliant green bile.
F. A. Mantel, Water Department, City of Memphis, Memphis, Tenn.—Coöperating on eosin methylene blue agar and gentian violet lactose broth.
Max Levine, Department of Bacteriology and Hygiene, Iowa State College, Ames, Iowa.
A. M. Buswell, State Water Survey Division, Urbana, Ill.
L. C. Bird, State Department of Health, Richmond, Va.
Geo. R. Taylor, Scranton Gas and Water Company, Scranton, Pa.
F. E. Hale, Mount Prospect Laboratory, Brooklyn, N. Y.
M. H. McCrady, Provincial Bureau of Health, Montreal, Canada.
H. E. Jordan, Indianapolis Water Company, Indianapolis, Ind.
H. Rosenthal, The Dallas Laboratories, Dallas, Tex.
A. V. Graf, Water Division, City of St. Louis, St. Louis, Mo.
W. H. Durbin, Terre Haute Water Works Company, Terre Haute, Ind.
J. C. Swenarton, Municipal Department of Health, Baltimore, Md.

II. A COMPARATIVE STUDY OF BRILLIANT GREEN BILE AND STANDARD LACTOSE BROTH

BY M. H. McCRADY[2]

This study was undertaken as part of the work of Committee No. 1 of the Association during the years 1923 and 1924. Its object was to determine the value of brilliant green lactose peptone bile (formula and procedure of Muer and Harris, Amer. Jour. Pub. Health, November, 1920) as compared with the standard lactose broth as usually employed, through coöperation of several laboratories located in various sections of the United States and Canada and handling various types of water.

Work of 1923

Associates: listed in JOURNAL, October, 1925, page 345.

The first consideration of these Associates was standardization of the medium to be employed. A study, by H. G. Dunham, F. E. Hale, H. E. Jordan and M. McCrady of nine samples of brilliant green obtained from various sources indicated the majority to be

[2] Chem.-Asst. Bact., Provincial Board of Health, Montreal, Quebec.

suitable for the medium and one dye was chosen for future work: brilliant green No. 184, Coleman and Bell, Norwood, Ohio. A comparison, by F. E. Hale and M. H. McCrady, of various dried oxgalls prepared by H. G. Dunham, with the coöperation of the Digestive Ferments Co., indicated a variation in results obtained with differently prepared oxgalls, but one was chosen which appeared to give results equivalent to those obtained with the specially prepared oxgall employed by the originators of the medium. This oxgall was designated as Special Oxgall No. 12224, and is now being supplied by the Digestive Ferments Company, Detroit, Mich., as Bacto-Oxgall.

The work accomplished by the associates with the special dye and the special oxgall, or the oxgall distributed by the originators of the

TABLE 1

ASSOCIATE	TUBES WITH EACH MEDIUM	RATIO: PRESUMPTIVE TUBES / CONFIRMED TUBES	
		Broth	Bile
C. R. Cox, Reading, Pa.	666	567/73	72/71
F. Stover, Louisville, Ky.	260	145/93	76/72
C. Burdick, Flint, Mich.	9	9/7	7/6
H. E. Jordan, Indianapolis, Ind.	198 broth 180 bile	81/69	36/33
N. J. Howard, Toronto, Ont.	280	121/111	95/92
M. H. McCrady, Montreal, Que.	240	82/70	67/60

medium, included a study of 1653 tubes of bile medium and a similar number of tubes of standard lactose broth planted with equal quantities of water, and complete confirmation of 1359 presumptives. These results are detailed in table 1.

A large amount of other data was contributed by the Associates, employing other oxgalls and other dyes. The total records received included study of 30,000 tubes planted and 8000 presumptives carried through the confirmation tests.

Work of 1924

Associates: listed in JOURNAL, October, 1925, pages 345 and 346. Employing the special dye, and the oxgall generously distributed,

TABLE 2

Comparison of brilliant green bile (10 per cent gas, seventy-two hours) and standard lactose broth (gas, forty-eight hours)

ASSOCIATE	WATER	SAMPLES	TUBES WITH EACH MEDIUM	PRESUMPTIVE TUBES / CONFIRMED TUBES	
				Broth	Brilliant green bile
G. F. Gilkinson, Kansas City	Surface R	38	266	212/182	199/197
	Surface S	38	266	111/100	88/85
	Surface ST	139	695	369/17	7/7
C. J. Lauter, Washington, D. C.	Surf R	85	255	205/152	153/126
	Surf F	80	400	100/32	32/26
	Surf FT	90	450	141/6	6/4
J. W. Bugbee, Providence, R. I.	Surf R	35	70	40/26	34/26
	Surf FT	79	158	41/0	0/0
M. H. McCrady, Montreal, Que.	Surf R	19	190	37/35	30/29
	Ground R	28	280	62/39	40/35
C. D. Howard, Concord, N. H.	Surface	34	68	22/18	25/14
	Ground	16	32	21/16	21/17
C. H. Burdick, Flint, Mich.	Surface	19	19	15/14	15/15
J. W. Kellogg, Raleigh, N. C.	Surf T	133	186	31/13	6/6
	Ground	68	88	31/30	20/20
P. Boynton, Clarksburg, W. Va.	Surface	5	33	21/21	16/16

TABLE 2—*Continued*

ASSOCIATE	WATER	SAMPLES	TUBES WITH EACH MEDIUM	PRESUMPTIVE TUBES / CONFIRMED TUBES	
				Broth	Brilliant green bile
W. M. Wallace, Detroit, Mich.....	Surf R	37	185	100/93	144/125
D. L. Maffitt, Des Moines, Ia.....	Surf R	26	58	40/30	38/31
J. H. Rider, Tucson, Ariz.....	Surf and Ground	88	440	198/24	144/26
C. C. Ruchoft, Chicago, Ill.....	Surf R	97	485	89/68	52/43
	Surf T	76	380	83/50	36/35
A. H. Straus, L. H. Enslow, Richmond, Va.	Ground	235	705	162/67*	127/73†
Frank Raab, Minneapolis, Minn.....	Surf R	117	351	181/181	173/170
	Surf F	42	126	82/81	63/63
	Surf FT	117	585	24/1	0/0
H. W. Clark, G. O. Adams, Lawrence, Mass. All samples Gas, forty-eight hours partially confirmed.....	Surf R	4	11	8/3	3/2
	Ground R	14	42	0/0	1/0
	Surf F or T	96	406	115/70	54/49
	Others	12	28	7/5	3/3
G. E. Willcomb, Albany, N. Y.....	Surf R	9	27	23/13	16/14
	Surf T	23	69	46/4	0/0

without cost to the Associates, by the Digestive Ferments Company, these various laboratories submitted records of study of 14000 tubes planted, with confirmation tests on over 4000 presumptives. These results are detailed in table 2.

Although some variation in the effectiveness of the bile medium is revealed by these figures, a lack of sensitivity as compared with the standard lactose broth being noticed with some waters, the medium apparently eliminates practically all spore-forming lactose fermenters, and seems to be well adapted for use with some waters. Improvement in composition or variation in procedure may render the medium more generally adaptable, but from the data here presented there appears to be a certain field of usefulness for this medium which well warrants consideration.

Preparation of medium

This medium included oxgall and brilliant green, the purpose of both these ingredients being to inhibit growth of spore-forming lactose fermenters, thus eliminating spurious presumptives to an extent which, according to the originators, would render presence of 10 per cent gas in seventy-two hours in the medium equivalent to a completely confirmed test of Standard Methods.

	grams
Distilled water	1000
Oxgall (dried)	50
Peptone	10
Lactose	10
Brilliant green	0.1

Heat 1 liter of distilled water in double boiler until water in outer vessel boils.

Add oxgall and peptone, stirring until all ingredients are dissolved.

Continue boiling for one hour.

Remove from flame and add lactose.

Filter through cotton flannel until clear.

To each liter of filtrate add 10 cc. of a 1 per cent solution of brilliant green.

Tube and sterilize in autoclave for fifteen minutes at 15 pounds pressure.

It is well to keep double boiler covered during heating to prevent undue evaporation.

III. BRILLIANT GREEN AS A CONFIRMATORY MEDIUM

BY H. E. JORDAN[3]

The 1923 Comparative Series tabulated by McCrady, gave from 1653 original plantings in lactose broth 61 per cent presumptives and 26 per cent complete B. coli, compared with 22 per cent presumptives and 20 per cent complete B. coli with brilliant green lactose bile. Forty-two per cent of the lactose broth presumptives completed as

[3] Sanitary Engineer, Indianapolis Water Co., Indianapolis, Ind.

compared with 95 per cent completed in the bile, but the total bile completions were only 77 per cent of the lactose broth total.

The 1924 series gave a lactose broth complete-brilliant green bile complete ratio of 100 : 91.

The original work on lactose bile was criticized because the medium appeared to inhibit some forms of the colon group. Its proponents suggested that such forms were attenuated and had no significance in water examination. It may be suggested, on the other hand, that standard lactose broth does not give 100 per cent picture of coli density as some forms are too weak to ferment even that medium.

For the purposes of this investigation it appeared necessary to submit a method that would give a density picture as near the standard procedure as could reasonably be attained, and at the same time clear up the confusion now existing on account of the wide divergence between original fermentations and complete colon group figures.

The fundamental concept should be the need of finding every organism of this group that has any vestige of metabolic ability left at the moment of sampling, to reduce to a minimum the number of false indications, to reduce the amount of materials now wasted in standard procedure and to shorten, if possible, the interval between sampling and reasonable confirmation of the nature of the organism studied. Several of the steps in standard procedure seem to be more traditional than effective determinants. Many cultures are handled that seem to be eliminated easily by inhibitive media, and it appears that even when the regular completed test is done it is uncertain whether symbiotic complexes or specific organisms have been found. With these facts in mind it was decided in April, 1924, to plant samples in an experimental series in standard lactose broth, and upon finding any amount of gas formation, carry on a parallel subcultural series. On the one hand all cultures should be looped into brilliant green or gentian violet lactose bile, and if fermentation occurred here, carry on the regular test for confirmation.

On the other hand, each original lactose broth tube in which fermentation occurred should be carried to confirmation according to Standard Methods.

The only difference, then, in the two series, was the interpolation in one of a brilliant green or gentian violet bile planting between original fermentation and endo plate.

Gentian violet was studied at the direction of the chairman of the Committee. A 1/20000 density was used as by Hall (6), except it

was added to lactose bile instead of lactose broth. Change in dye used was at month intervals. Seventeen hundred and ninety-three original fermented lactose broths were planted in the green bile and 713 in the violet bile. No material difference was noted.

The expected value of this is based upon a study of three years analysis of the subcultural characteristics of colon group as found at Indianapolis. In the raw water 99.3 per cent of the original fermentations in lactose broth grew on endo, and 81 per cent are completed colon group organisms.

In the filter plant effluent after chlorination, only 21.8 per cent of the original fermented tubes are successfully subcultured to any growth on endo plate and only 3.5 per cent of the original fermenting group complete.

TABLE 3

	ORIGINAL LACTOSE BROTH FERMENTATIONS	NORMAL SUBCULTURING		MODIFIED METHOD		
		Growing on endo	Complete B. coli	Growing in lactose bile with dye	Growing on endo	Complete B. coli
Filtered water	774	663	270	293	292	271
Filtered water after chlorination	760	64	9	8	8	8
Tap water	972	660	260	293	291	257
Total	2,506	1,387	539	594	590	536

It must not only be obvious that such a wide divergence between original fermentations and complete colon group organisms is disconcerting to laboratory operators, but the use of so many endo plates that give no growth is wasteful of energy, time, and materials.

The parallel series was carried on through January, 1925. Eighty-five hundred and eighty-nine tubes were planted from filtered water before and after chlorination and tap water. The quantity planted was large enough to get frequently fermented lactose broth tubes. Raw and settled water were not studied.

The performance of the various groups is shown in table 3.

Of the total original fermentations 55.5 per cent grew on endo, and 21.5 per cent completed. In the substitute procedure, only 23.7 per cent fermented the dye-containing lactose bile, 22.5 per cent

grew on endo and 21.4 per cent confirmed. Ninety-nine per cent of the organisms growing on dye-containing lactose bile grew on endo and 90 per cent were complete colon group organisms.

Four cultures fermenting the dye-containing broth failed to grow on endo. This is probably due to technical error.

The difference in the total number completed is so small as to be within the limit of error in manipulation. Either 1/10000 brilliant green, or 1/20000 gentian violet lactose bile does not seem to inhibit colon group organisms that have first had the opportunity to set up metabolic activity in Standard Broth. It is evident, on the contrary, that, in the density used, some organisms ferment the broth and grow on Endo plate that do not go to completion. This occurred in the case of 44 cultures that did not grow in secondary lactose broth tube after growing on endo. Not a single spore forming culture passed the restraining broth.

From the standpoint of labor involved, the use of the dye media eliminated 76 per cent of the endo-plate plantings. It is matter of opinion whether one prefers to use a Petri dish containing solid media to a tube containing liquid for this step in the diagnosis.

Conclusions

Concerning the parallel original planting series directed by McCrady the following general deductions can be made.

1. Lactose broth gives more presumptive tests than green bile.
2. Green bile presumptives give a higher percentage of complete tests than lactose broth. Therefore its significance in the earlier stages of the diagnosis is greater.
3. The total number of complete tests for colon group organisms will be higher when using lactose broth as an original planting medium than when using green bile.
4. Green bile appears to extend its selective inhibition to the attenuated forms of the colon group. (Note the ratio of completion in raw surface waters and chlorinated filtered waters.)

Concerning the studies on variation of standard methods by interpolation of green or violet bile following growth in lactose broth, the following deductions can be made.

1. Its use eliminates the large number of endo plates on which no growth occurs.
2. Spore forming organisms are eliminated.

3. The per cent of completed brilliant green cultures to lactose broth cultures is 99.5—errors in manipulation could account for this.

It can be concluded that with the water studied, brilliant green bile does not inhibit any organisms of the colon group when used in this fashion.

4. The concentrations of brilliant green (1/10000) and bile (5 per cent) used do not seem to be such as to be absolutely specific for colon group organisms. Ten per cent of the cultures growing on endo did not complete. Time is actually saved in the complete test, however, because it is not necessary to grow a special culture for spores.

It is proposed to carry on the coöperative study during 1925 and 1926. This will be ample to include any modifications that may be developed in the following edition of Standard Methods.

1. The first problem to be attacked is a modification of the bile-dye combination in an effort to make growth on it more specific than it now is. This would seem possible by a slight reduction of the bile density—reducing its protective effect, or by increasing the dye density—increasing the inhibitive effect.

It may, however, develop that the specificity of the medium is all that can be expected. This study is to be directed by Mr. Dunham.

2. The second problem is a further study of the hydrogen ion concentration of the medium. The researches of Stearn and Stearn, as well as Winslow and Dolloff, indicate that this may be a fruitful field. This study will be directed by Mr. Dunham.

3. The third problem is a more complete verification of the results of bile-dye interpolation that was studied at Indianapolis, in 1924. While the large number of tests carried on there indicate its usefulness on water in that district, the method must be confirmed by a number of other observers, before it can be proposed as a step in Standard Methods. This study will be directed by Mr. Jordan.

A condensed summary of the previous investigations

(Numbers refer to reference appended)

(1) It is evident that the bile salts, and especially their acids, exert a strong restraining action over the common bacteria which grow at blood heat, and that except for Glycin (which mildly restrains much as a sugar retards bacterial action), the actual bactericidal action lies in the cholic acid radical of these salts.

It is evident, therefore, that either of the bile salts, or a mixture may be employed. In fact, a plain bile as a liquid restraining medium may be used. The restraining action is selective. It favors the increase of B. coli, retards

the growth of certain streptococci, and actually kills off the majority of other species which grow at 37°C.

(2) Rejuvenation in suitable media followed by transplanting to lactose bile will sometimes prove the presence of B. coli, usually attenuated, not shown by the lactose bile in direct tests.

Gas formation in lactose bile after transplanting from the plain broth or dextrose broth is not always certain, even when B. coli is present, on account of interfering growths in the original medium.

(3) The determination of gas-forming bacteria in water by means of lactose bile gives results which represent the relative degree of contamination of dangerous or recent origin. While of especial value in judging the degrees of pollution present, it does not show the presence of gas-formers other than the colon group and does not often indicate B. coli in an attenuated state.

Any difference in the results obtained in lactose bile compared with those found by transplanting within twelve hours from the liver broth into a second set of lactose bile tubes gives a fairly accurate idea of the amount of attenuated B. coli present. Negative results in both sets of bile tubes and positive results in the liver broth usually show that the gas-producing bacteria present are not of the colon group.

(4) Lactose bile containing 5 per cent dried oxgall is preferable to 10 per cent media.

The formation of gas is more rapid and greater in amount. Positive tests appear in higher dilutions. Attenuated B. coli is more readily shown.

Interference by other bacteria is less evident, especially by streptococci.

The 5 per cent bile makes a clearer media without interference from sediment. In sterilization, foaming is less apt to occur, and cotton plugs are not forced out from the tubes.

(5) Ritter reported a series of samples subjected to a parallel planting in lactose broth and lactose bile, and found that: when, in one of the two, fermentation with gas is negative, B. coli is generally absent; when both are positive 75 per cent of the tests confirm; when both are positive in twenty-four hours 98 per cent confirm.

A number of investigators have studied the effect of dyes in culture media on various organisms. Churchman, Kligler, Krumreide, Pratt, and others have laid down a foundation that may be summarized as follows:

(6) The triphenylmethane dyes are toxic to bacteria. Their reaction is partially specific. In general they restrain the growth of Gram-positive bacteria and have no effect upon the Gram-negative group. The different dyes in the series possess a similar differential action. The action appears at different dilutions according to the dye employed.

At appropriate dilutions, no one dye is preceptibly more differential than another.

Composition and reaction of the medium exerts a marked influence on antiseptic properties. The higher the concentration of nitrogenous compounds, the lower the effective concentration of the dye, probably on account of alteration of the bacterial cell.

It has not been possible to combine indicator function with bacteriostatic power.

(7) The concentration of certain dyes having an inhibitive effect has been found to be far less in lactose broth than in lactose bile. It has been shown that brilliant green and gentian violet can be used in lactose bile in concentrations of 1:1000 without inhibiting B. coli, while in lactose broth the density must be diminished to 1:50,000 in the case of gentian violet—and 1:1,000,000 in the case of brilliant green.

(These variations in inhibitive density when combined with bile would suggest that composition and concentration of bile is a very material factor in the combination and one deserving further study.)

(8) Fermentation of sugar broth may be produced by two organisms growing in symbiosis, neither of which acting alone can produce gas. A progressive action seems to be clearly indicated in these cases. The degradation of the sugar is begun by an acid former, and in the course of this decomposition, substances are formed which are utilizable by the gas former and gas production results. The gas former in this pair—it is understood—is incapable of gas production when grown alone.

Later studies showed these combinations to consist of at least one organism capable of acid production in lactose and one organism, which may ferment dextrose with gas production, but produces no gas in lactose when alone.

The acid forming organisms were, for the most part, Gram-positive, nonmotile, non-sporing, chiefly steptococci, growing readily on the usual laboratory media. The gas forming organisms were all bacilli, growing fairly well on ordinary media, mostly Gram-negative. Of all Gram-positive bacilli found, only about 10 per cent had any effect upon the gas production of the complex. Organisms belonging to the types shown occur widely distributed in nature and in locations from which they may readily enter a water supply.

(9) There are gradations of dye sensitiveness, from very striking cases among strongly Gram-positive organisms to other species which are very resistant to the action of dyes. These latter are almost always Gram-negative organisms.

The most plausible inference would be to assume the existence of corresponding acid groups in the structure of the organisms with which basic groups would tend to unite.

The amino-acid composition of proteins (bacterial or other) and allied amphoteric substances furnish just such acid groups. The dye molecule combined with the bacterial protein is only very difficultly destroyed so that the organism finds itself unable to liberate that portion of the dye which it might utilize in its own metabolism, and by this liberation free again the "receptor" or point of attack for basic nitrogenous nutrient material. This results in a sort of starvation or inhibition of the organism.

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WELDING A CRACKED 48-INCH CAST IRON PIPE UNDER 20 FEET OF EARTH[1]

By Wm. W. Brush[2]

GENERAL DESCRIPTION

As a part of the Croton system, the City of New York has eight 48-inch cast iron mains running south from what is known as the 135th Street gatehouse, located at the corner of Convent Avenue, Manhattan (figure 1). Where the mains leave the gatehouse there is more than 20 feet of earth and rock fill over the top of the 48-inch pipe lines, and there have been several cracked pipes under this heavy fill since the mains were laid nearly forty years ago. The cracks have been caused by the external loads, as the head of water is only about 30 feet where the mains leave the gatehouse. The pipes are the usual bell and spigot type, and have a thickness of $1\frac{1}{4}$ inches, or equivalent to about Class B American Water Works Association standard. Previous to 1925 it has been customary to excavate from the surface and remove any broken pipe. The last repair of this character was accomplished in 1923 at a cost of about $8000. The high cost of repair is due to the character and depth of the excavated material and location of work. A cracked pipe was repaired this year by electric welding in place at a cost of about ten per cent of the cost of removal and replacement of the broken pipe. It is believed this repair job is the first one of its kind ever undertaken on a cast iron main and is therefore of unusual interest.

BREAK IN MAIN

On February 28, 1925, a large leak showed in cellars south of the 135th Street gatehouse, and by shutting down successively the 48-inch mains it was found to be on the next to the most westerly of the eight 48-inch mains. On March 5 the manhole cover on this line,

[1] Presented before the New York Section meeting, September 26, 1925.

[2] Deputy Chief Engineer, Department of Water Supply, Gas & Electricity, New York, N. Y.

located in the gatehouse, was removed, and an examination of the inside of the pipe showed that the pipe was split along the bottom, extending from the bell end for a distance of 5½ feet, the broken end being 77 feet south of the manhole. A substantial flow of ground water was entering the pipe through the crack. This ground water is probably largely leakage from the gatehouse, and twelve mains that leave the gatehouse. Four of these mains run west and then south and are old croton aqueduct mains.

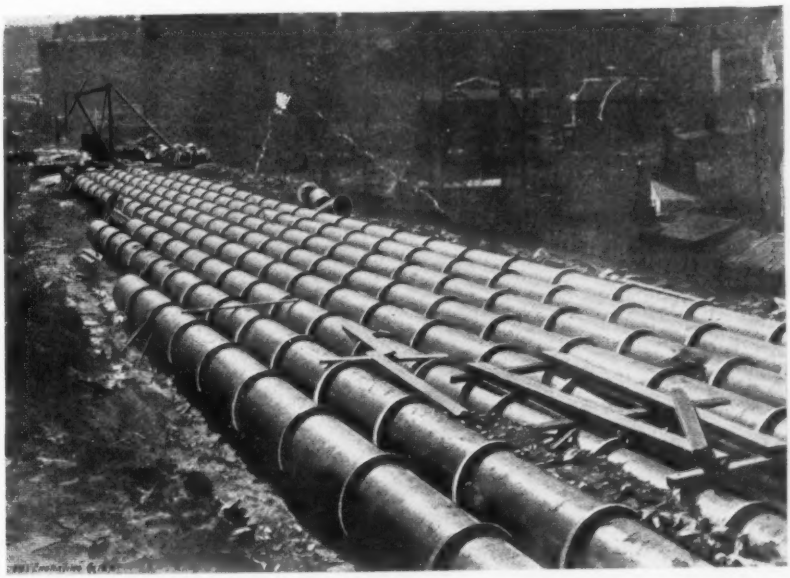

FIG. 1. EIGHT 48-INCH CAST IRON MAINS LAID IN CONVENT AVENUE IN ABOUT 1888

ADOPTED METHOD OF REPAIR

Consideration had been given in 1923 to the repair by welding of the main that had cracked that year, but the crack was on the top, and no welding of this kind of an overhead crack had been previously done. When it was found the new crack was on the bottom the question of welding the pipe in place was taken up. It was believed that electric welding was the only type that probably would not generate enough heat to melt the lead out of the joint, and the Electric Welding Company of America, foot of Court Street, Brooklyn, through its chief engineer, Mr. William Schenstrom, advised

that the repair by welding was considered practicable, and that his company would agree to make the repair for $880 and guarantee a successful job, no payment to be made if the crack was not satisfactorily closed. After considerable discussion and investigation of difficult welding work successfully executed by this company, an order for the work was issued under date of April 24. The main was not urgently needed and there was no necessity to save time on this job.

PRELIMINARY WORK

The ground water stood at about the center of the main, and before welding could be undertaken the water level had to be lowered below the bottom of the pipe to prevent inflow and remove the cold water from contact with the iron to be welded. Two 2-inch holes were tapped in the bottom of the broken length of pipe and short suction lengths of $1\frac{1}{2}$-inch pipe placed in these holes, and carried about 2 feet below the bottom of the pipe. These short lengths were connected to 2-inch pipe which was laid on the bottom of the 48-inch pipe to the manhole, and connected to a centrifugal pump driven by an electric motor. After about sixteen hours pumping the amount of water that was to be removed was less than that which would feed the pump, running continuously, and it was found necessary to substitute a diaphragm pump, as the centrifugal pump would lose its charge and would not then automatically pick it up again. The seepage, which may have been largely leakage from other mains, represented about 20 gallons per minute. The diaphragm pump was operated continuously throughout the time that the welding work was in operation.

WELDING WORK TO REPAIR THE CRACK

At the end of the crack a $\frac{3}{4}$-inch hole was bored through the pipe to prevent the crack continuing further along the pipe. Then a "V" shaped groove was cut in the pipe following the line of the crack. This groove was two inches wide at the top, and came to a point at the outside of the pipe. Manganese bronze was welded into this "V" cut and brought up to the level of the inside of the pipe. This welding would not give sufficient strength, as the welding metal does not adhere to the cast iron as strongly as to steel. It was therefore necessary to place a reinforcing steel plate on the bottom over the crack. This plate is $\frac{7}{8}$ inches thick, and was machined to the curve

of the pipe. In the plate and near the edges there are fourteen 1-inch holes through which the plate was welded to steel stud bolts tapped into the pipe. Three-eighths-inch stud bolts were placed in the pipe along the edges of the plate and cut off about flush with the pipe. The plate was then welded along its edges to these bolts, and the cast iron between the stud bolts. These features are shown in figure 2. The photograph in figure 3 shows this work as completed.

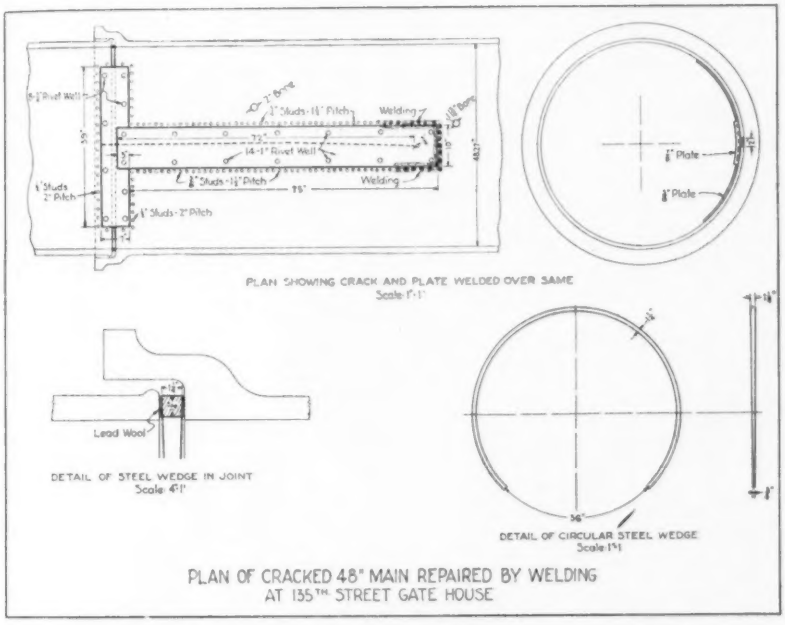
Welding
Welding
Lead Wool
PLAN SHOWING CRACK AND PLATE WELDED OVER SAME
DETAIL OF STEEL WEDGE IN JOINT
DETAIL OF CIRCULAR STEEL WEDGE
PLAN OF CRACKED 48" MAIN REPAIRED BY WELDING
AT 135TH STREET GATE HOUSE

FIG. 2. DETAILED PLAN OF REPAIRING CRACK IN 48-INCH MAIN

MAKING THE JOINT WATERTIGHT

As the bell was cracked, as the lead might have moved in the joint, and as the welding might melt the lead, it was necessary to make the joint tight from the inside. At the top of the pipe the joint was opened up about $1\frac{3}{4}$ inches, and at the bottom about $\frac{1}{4}$ inch. The upper part of the joint was too wide to be satisfactorily caulked with lead wool. A circular steel wedge or dutchman was made, $1\frac{1}{4}$ inches wide at its widest part, and tapered down to $\frac{1}{4}$ inch at the two ends. This wedge extended about three-quarters of the distance around the pipe joint. The bottom of the joint, including a couple of inches of

the ends of the steel wedge, was covered by a $\frac{3}{8}$ inch steel plate 7 inches wide, which was welded to the pipe by use of stud bolts in a manner similar to the welding of the bottom plate. From the end

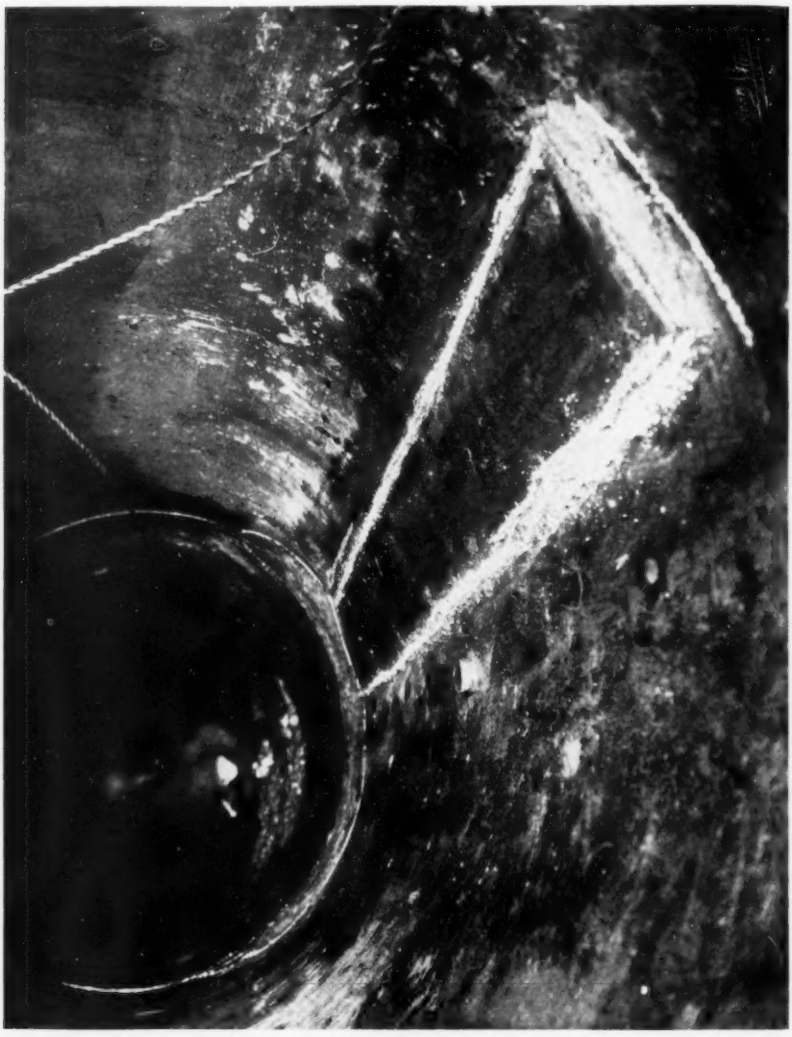

FIG. 3. INTERIOR VIEW OF PIPE, SHOWING BOTTOM WELD

of the weld lead wool was used to caulk each side of the wedge to make a watertight joint. Figure 4 shows the lower part of the joint, and figure 5 the upper part of the joint.

TIME OF COMPLETION AND RESULTS

The work was completed on June 9, and required one hundred and one man days of skilled labor. On June 10 the water was again

FIG. 4. WELD OF JOINT SHOWN IN THE FOREGROUND

turned on, and the main continued in service until June 17, when it was shut down and the interior examined. There was no evidence

of inflow or seepage of ground water, and the job was found to be in excellent condition. Since then the main has been used continuously.

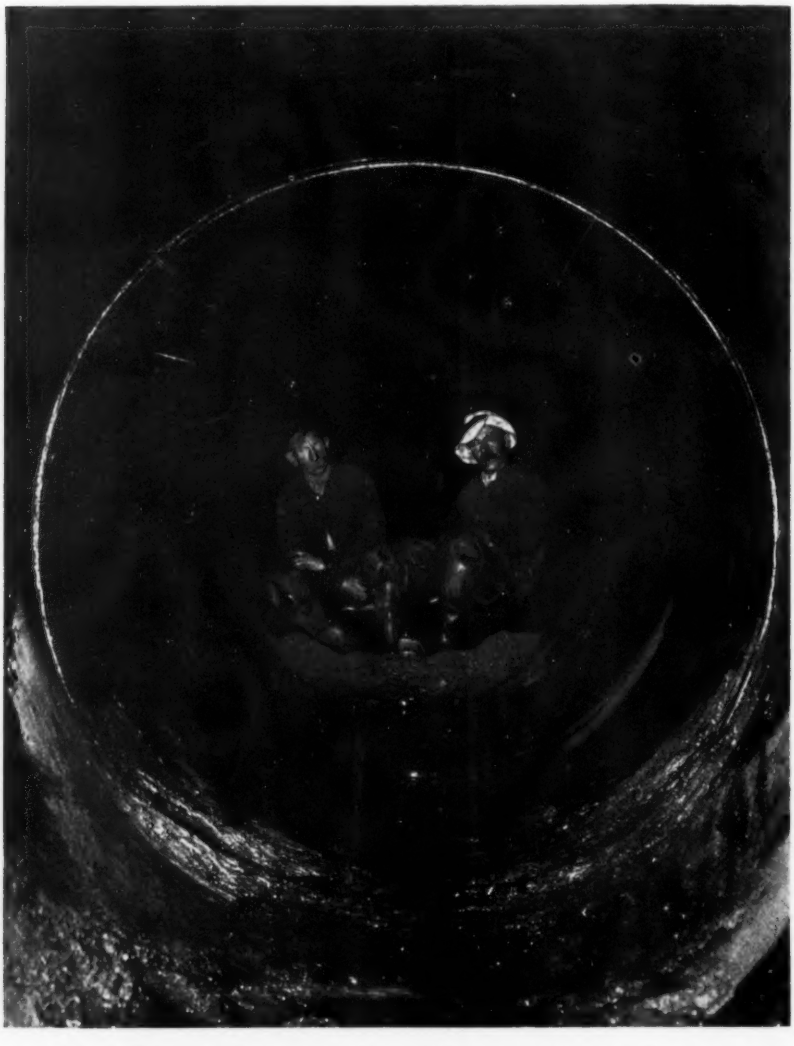

FIG. 5. VIEW OF UPPER AND LOWER PART OF JOINT AS REPAIRED

Consideration was given to the advisability of grouting under the pipe through the two holes used for pumping the water, but it was decided not to use grout, as it would be impossible to tell what kind of a foundation would be formed by the grout.

Mr. Schenstrom, the chief engineer of the welding company, is entitled to a great deal of credit for devising the plan of welding, and successfully carrying it through under very difficult working conditions, and credit is also specially due to Mr. John F. Mead, superintendent in charge of repairs to the distribution system, Manhattan, who was in charge of this work, and very satisfactorily aided in planning and executing it.

DISCUSSION

WM. A. MCCAFFREY:[3] I should like to ask Mr. Brush how they got on the inside of that pipe.

W. W. BRUSH:[2] There is a manhole in the gatehouse. The manhole was of the usual size and I know it was a tight fit for me to get through. Our Superintendent who worked with Mr. Schenstrom on this job, weighs 260 pounds or thereabouts and he could not get through the manhole. In this case we had no expense to get at the pipe, and the expense other than the actual welding was very largely in the pumping part of the job. Mr. Schenstrom in estimating on the cost of the job did not know the amount of water that was outside and could not tell what the job was going to cost, but he made his estimate and stayed with the job, even though the difficulties were very much greater than were anticipated on account of the water.

G. C. ANDREWS:[4] You said your previous break was at the top of the pipe. Did you consider that you could weld that?

W. W. BRUSH:[2] Yes, but the greater part of the cost of repairing the previous pipe was making the excavation and we felt that as nobody had successfully welded cast iron pipe in place, under those particular conditions, it was not advisable to weld it. When we had spent several thousand dollars on excavation, we thought we had better take out the broken pipe and put in a new length.

I should like to ask Mr. Schenstrom to state for my information and for yours whether he thinks a similar crack on the top of the pipe could be as successfully repaired.

[3] Superintendent, Water Works, Oswego, N. Y.

[4] Water Commissioner, Buffalo, N. Y.

WILLIAM SCHENSTROM:[5] Working directly overhead would be rather difficult. If it were anywhere but directly overhead, it could be done. It would be rather difficult with cast iron to get a perfect weld overhead.

W. W. BRUSH:[2] Would you, Mr. Schenstrom, under conditions such as we have in those pipe lines, attempt the job of welding if the crack were directly overhead, by working from the inside?

WILLIAM SCHENSTROM:[5] Yes, I would attempt the job from the inside and would then rely on the plates more than on the weld itself in the cast iron to make the job strong enough. I would use some copper alloy in the crack to make it tight and then use plates to give it strength.

W. W. BRUSH:[2] I should like to ask, Mr. Schenstrom, whether he has any idea of what percentage of the strength of the cast iron iron section would be made available through the initial weld of the crack, leaving out the plate in this particular job at the bottom, that is, have you any idea from experience in other work, what would be the percentage of strength that we would have there from just the weld without the plate over it.

W. W. SCHENSTROM:[5] In years gone by we used to do cast iron welding without any plates at all and we have a number of jobs over a period of years that we can look back on and the welds must have produced at least 80 to 85 per cent strength to do the work that they have done over a period of years.

B. C. LITTLE:[6] Mr. Chairman, we have experimented with welding leaks in water mains in perhaps two or three different respects from the case Mr. Brush has there.

We have welded pipe while still in position with the water in. It has been steel pipe, and we have done it from the outside and been very successful. We merely put a plate over the hole and put a wooden plug into the hole where it has been leaking, which stops the leak temporarily. Then we put a steel patch on top of that and weld

[5] Chief Engineer, Electric Welding Company of America, Brooklyn, N. Y.

[6] Superintendent, Water Works, Rochester, N. Y., Secretary, American Water Works Association.

right around it. I am wondering why, with that steel plate you put in the bottom of your cast iron pipe and welded it all around, it was necessary to use stud bolts. If that was not strong enough, I do not see what was the idea of getting additional strength. You said there was only about 30 feet head to overcome. What was the strength there beyond the weld of the steel plate to the cast iron?

W. W. BRUSH:[2] I will ask Mr. Schenstrom to explain why he put the plate in. We gave them the job to make it tight and we did not design the welding because he had had a great deal of experience and we had not. I understood from him that the stud bolts were put in because he felt it was a surer job as to the adhesion of the welding material to the stud bolts as compared with the cast iron. You see we had there, assuming that the weld in the crack itself was not going to take up the stress, the welding material at the edge of the plate. I will ask Mr. Schenstrom to say why he used the stud bolts.

WILLIAM SCHENSTROM:[5] We used the stud bolts for the reason that we run up against so many different kinds of cast iron. Cast iron runs unevenly and where the quality of the cast iron is poor, the weld is poor. Where there is a lot of sand and slag we get a very poor weld and if one strikes a few of those bad spots, it weakens the total strength of the welded area, so we use these stud bolts as insurance to raise the average, as we figure at the points where these stud bolts are inserted and cut off, we develop the full strength right over that area of say 45,000 pounds, so it is more as an insurance than anything else.

The reasons why we used the plates in this instance were several. One was that this pipe was forty years old and another was that there had been some pressure from the outside that had forced the pipe to change its position and we wanted to be sure that the pipe at that point would be strong enough to withstand not only the head of the water, but any external strain that might be put on it at that point.

W. W. BRUSH:[2] The 45,000 pounds you speak of refers to the tensile strength of the welding material per square inch, I presume.

WILLIAM SCHENSTROM:[5] The joint between the studs and the welding material for an area of $\frac{3}{4}$ inch in diameter.

WM. A. MCCAFFREY:[3] Did you make an examination as to what caused the crack itself besides the settlement?

W. W. BRUSH:[2] We did not make any examination of that length of pipe. We have had a number of breaks in those pipe lines. You see those pipe lines, as I say, are under some twenty or more feet of fill. Under such conditions your pipe is probably pretty close, or is beyond the safe load, when you consider safe load on the basis of retaining the factor of safety that you figure in cast iron pipe of approximately five or six.

Our experience with those pipe breaks had indicated that in each case they have been due to an external condition and not to any defective material. The pipe is of excellent cast iron based upon earlier breaks, but the fill is a combination of rock and earth and the pipe has leaked due to some settlement and a further settlement has occurred and the pipe has come down on points of rock which has concentrated the load on that point and resulted in a stress in the metal above the strength of the metal.

We talk about our factor of safety in our pipes. The factor of safety, as I said, is five or six, after making allowance for water hammer and for the pressure to which the pipe is normally subjected. Then we lay the pipe and we lay it in a rock trench and, putting the pipe on a couple of wooden supports for each length, we hope and endeavor through our inspectors to get enough earth underneath so the pipe will not come in contact with any rock. Or, we put it in rock filled trenches and again support it on wooden timbers and again we hope it is going to stay where we put it and not come down so that it will be resting on a point instead of bearing generally on the material below it. Then we say there is a pipe that has a factor of safety of six, with an allowance for water hammer of perhaps twice the normal pressure. If the pipe breaks, our computations are all right, but our methods of laying are entirely inadequate for the safety of the structure. The supporting power of our material is not equal to what is necessary to maintain that pipe in the place in which we put it. Where such supporting power is sufficient, there may be other excavations made in the vicinity at a lower level so that some of the material is carried down to the lower level and the pipe settles with it and comes in contact with an unyielding point or deflects at the joints and there we have a condition where the factor of safety is depended upon to make up for the stress that results

in the metal of the pipe. It is no wonder that our cast iron pipes give way under those conditions. In the larger cities the conditions are much more severe than in the smaller communities, because we have a multitude of sub-surface structures and therefore we naturally have many more breaks than the smaller communities.

New York has had a number of breaks this year that have had a great deal of news value. When you stop several thousand people from going through a subway when they normally travel that way, that means important news, not from the standpoint of the water department, but from the standpoint of the public generally. Again, you have a break that makes you tear up Fifth Avenue at its busiest point and put the street out of use for several weeks. That has news value. So, while our Manhattan breaks have had more news value, they have not been greater this year than in previous years. In New York City the mains are not breaking any more frequently this year than in previous years. We have several hundred breaks a year. Our large pipe breaks run twenty or less. But taking all sizes, we have several hundred and it is a very important problem, first, as to what should be the practice in supporting pipes when they are first laid, and, second, what material should be used to minimize the danger of breakage and the damage and inconvenience caused to a community by the breakage in the mains.

J. WALTER ACKERMAN:[7] The problem Mr. Brush has related to us reminds me of some experience I have had in the past with an old 24-inch line that was the sole supply of the town. Originally the line was laid as a siphon line. I have heard the statement made that at the time it was built it was the longest siphon line at that time in operation. It was laid on the contour of the ground which covered anywhere from 2 to 3 feet. It was 24 inches and thinner than any pipe that I have ever seen. Of course, being a siphon line, it would only deliver a small amount of water and, as time went on, the town had to have more water and they put pressure on the other end of it and turned it into a force main.

After the pipe became about thirty-five or forty years old, it began to break by longitudinal cracks sometimes, and once or twice it broke right square off right around. But if that pipe stopped, the whole city supply stopped, so means had to be at hand to keep it going.

[7] City Manager, Watertown, N. Y.

Finally, as a last resort, I designed split sleeves. They were rather cumbersome things, but they answered the purpose. Whenever we discovered a spring in some farmer's field, we dug it out and got a pump to take it out as well as we could, and we slipped these sleeves around it and put the stuffing box rings in with packing and screwed them up tight and turned off the valves and the job was done in a short time. That was a case where I do not think welding could have been utilized, because everybody had to wear a bathing suit or a rubber coat.

Mr. Brush mentioned one thing in reference to a centrifugal pump, that when it lost its suction you would have to wait to prime it. I wonder whether you are all familiar with a little instrument (I can not remember the name of it, but I have one and have used it for that same purpose) which is an air exhauster. I use it where a foot valve cannot be handily used. You simply have a small electric motor attached and a barrel of water and you start this thing going. It exhausts the air and you will not have any trouble with losing your suction. The minute water closes the end of your suction pipe you start this thing in operation.

IMPROVEMENT OF PUMPING STATION GROUNDS[1]

TOPICAL DISCUSSION

H. P. BOHMANN: If it is in order, I would like to bring something before this Convention at this time relative to the improvement of pumping station grounds, although the subject may have been up for discussion this morning. The City of Milwaukee has just completed a new pumping station building, the cost of which, including grounds and equipment in the station, amounts to two and a quarter million dollars in round figures. About one-third of the ground is occupied by the pumping station and the remainder as yet unimproved, although the department had contemplated beautifying the balance of the site. We have a few hard-headed citizens in Milwaukee who seem to think that the grounds ought to be utilized for the erection of a trade school, thereby saving the expense of buying another piece of ground. I have been opposed to this scheme because I do not think that a trade school should be located immediately in front of a pumping station and in close proximity to it. These grounds ought to make a nice setting for the pumping station building and should be converted into a park. I have opposed locating a school building on the pumping station grounds. Furthermore, the trade school will have boys ranging from fourteen to eighteen years of age and I am afraid they will over-run our property and the station. We have had considerable trouble with school children going through the station. From an inventory made the first of the year we can account for only 75 per cent of our small tools. The school children have removed the mirrors off the wall in the toilet room, have carried away the toilet fixtures and everything they can lay their hands on. I am afraid that if we have a trade school on the same grounds with the pumping station the boys will have a nice kit of tools when they graduate and therefore wish to know whether the members of this Association favor a school building on a pumping station grounds. I would like to bring out the sentiment of this division on the question asked.

[1] Presented before the Plant Management and Operation Division, Louisville Convention, April 29, 1925.

W. S. CRAMER: I would ask for a show of hands as to those who favor beautifying the grounds. That would be the easiest way to get at it. Mr. Bohmann simply wants an expression from this assembly that he may take back with him. Please give us a show of hands, those who would favor beautifying the grounds rather than using them for school purposes. Mr. Bohmann, I think you have our unanimous approval.

S. H. TAYLOR: In New Bedford we had a pumping station which occupied a whole city block. When built it was in an outlying part of the city. As the city grew around it and space became more valuable, other departments began to encroach upon it. First, a fire station took a corner, then a schoolhouse took a large slice and finally a playground another part. Now we have left only the land covered by the building and the controlling valves. Because of the children from the school and playground, it is next to impossible to keep the place in good condition, in spite of a 6 foot wire fence built around what we have left.

I say, by all means beautify the grounds and keep off all encroachments, especially schools which bring so many children who interfere with keeping the place in order.

VALVES ON FIRE HYDRANTS[1]

TOPICAL DISCUSSION

H. P. BOHMANN: I would like to find out the practice in other cities regarding the installation of independent valves on hydrant pipe? Several years ago we started to place independent valves on all hydrant pipes of newly laid mains regardless of whether the hydrant was in a residence or business section of the city. Unfortunately, in our high value district which is the older and main business section of the city no valves were placed on hydrant pipes. It would be quite expensive to place valves at the present time in view of the permanent pavements, interruption of service, etc., although that is where they really belong. I would like to find out what the practice is in other cities, whether valves are placed on all sizes of mains and in all districts or only in certain sections of the city or on hydrant pipes only in connection with water mains larger than 6 inches in diameter.

J. F. CHRISTY: We practice that in every place, placing a valve on every hydrant, no matter where the hydrant goes. We found, as no doubt many others have who have had similar experience with hydrants, that we had to buy runways, tracks, etc., and we adopted that system several years ago and are not only placing it on the new hydrants, but, as we are making repairs on the hydrants that are without the valves, we are putting valves on the old hydrants. We also hope to have, in a few years time, all our hydrants in the city of Jonesboro, with independent valves. It is a little expensive, in a way, but I think it is money well spent. The time might come when, in the case of a bad fire, or something, there is no telling what might happen and it could, in many respects, give rise to the urgent need for those hydrant valves. When they would need them it might be at some time when it might mean a great deal, and I think it is money well spent in every respect.

[1] Presented before the Fire Protection Division, Louisville Convention, April 29, 1925.

Dow R. GWINN: Davenport, Iowa, started that practice years ago. I did not know enough to do it in my earlier days in the water works business, but later on, every 12 inch main we laid with hydrants, we put a separate valve on, and as time went on, we got more experience, and then we put a separate valve on every hydrant that we put in; when there were any changes on the old hydrant branch, we put a valve on. We found it was mighty good practice. It is better to shut off one hydrant than three or four and if you shut off a whole district, you are liable to have a fire alarm come along in that district and have some trouble with the Fire Department. If I were going to build another water works plant to-day, I would provide a valve on every fire hydrant, regardless of the size of the pipe. I understand that Indianapolis has gone into the practice of putting valves on all hydrants wherever they have an opportunity.

E. E. NORMAN: We have made a practice in Kalamazoo of putting a valve on every hydrant, regardless of the size of the main. We feel that it is money well spent.

MR. ALBERT: In Knoxville there are many fire hydrants which have no valves on them. We find, as one of the other gentlemen said, that in making repairs it is advisable to install valves on these fire hydrants. Whether Knoxville has more reckless driving than any other city or not, I do not know, but we have experienced of late the destruction of a number of fire hydrants due to their being run into by trucks and other motor vehicles. In many cases we have had to cut off as many as eight blocks to stop the flow of water. We have a number of old hydrants which have to be replaced and in making the replacements we invariably put valves on the front of the fire hydrants. The point which has not been brought out so far in the discussion is that the presence of the valve in front of the fire hydrant, whether new or old, enables repairs of the fire hydrant to be made at less cost; because you do not have to cut your improved pavement. All of our improvement district work requires that the lead to the fire hydrant must have a valve on it, so that in making any repairs or replacements, the improvement district pavement will not be cut thereafter.

H. P. BOHMANN: In connection with the question asked I wish to let the members of this Association know that as far as the City of

Milwaukee is concerned the expense of inserting valves on all existing hydrant pipes would be a very big item of expenditure, as we have at least three thousand hydrants with no independent valves and all under permanent pavements. Our system is over fifty years old.

B. C. LITTLE: There is some question about the need of valves in all hydrants. I think there is no question about the desirability of it in the business district, but in the residential district, if you have your mains well gated and a hydrant is broken, it means that on the street in front of the residences you have only to shut out one block, if you have a gate at each end of that block. The hydrant, that is, a good hydrant, if it is broken, does not let the water escape; all you have to do is to shut off your gate at each end of the street during the time you are taking out that hydrant and putting in a new one; it does not mean digging up the street. It is a good thing to have a gate in front of every hydrant, but it is a question of expense. I do not think it is especially necessary in purely residential districts.

W. S. CRAMER: I think it is an imperative duty that on feeder lines of 10 inches we will say, and speaking of the smaller cities, 10 inches and larger should have a valve on every hydrant branch, and in a congested district in most of your smaller towns, I think you should, as fast as possible see that the hydrants in that locality all have independent valves on them, but there is very much to be said in favor of what Mr. Little has said about the residential districts and a great deal to be said about the older towns. If these have 100 or 200 hydrants installed in the earlier days of the plant, about 50 years ago, considerable expense would be attached to changing them, but in a mercantile, high value district we have valves placed on even the older hydrants, and on the new feeder lines every hydrant on a 10 inch main or larger has a valve. I think that is necessary because you are dependent on that feeder line for considerable territory.

H. P. BOHMANN: In the City of Milwaukee when we had extremely cold weather and little snow, several hydrant pipes broke, and in every case the pipe broke about midway between the hydrant and the main, so that we now set the independent valve close to the main on the strength of the experience we have had. It seemed strange that in all cases where the hydrant pipe did break, the break was about

half way between the main and the hydrant. It was therefore deemed good policy to place the valve close to the main and not, as they do in many cases, near the hydrant. Of course, this affects only such cities as are in districts where they are subject to extremely cold weather.

S. H. TAYLOR: There is one point that I have not yet heard brought out. In many systems, especially the older ones, the non-compression type of hydrant is used. When the hydrant is broken off the flow of water is apt to be so great that it is impossible to get at a valve on the hydrant connection. This means that the whole section has to be shut off, the independent valve closed, then the water let on to the section again. It is better, in my opinion, to make smaller sections so that only a few hydrants would be involved in shutting off any section. This would be of benefit not only in case of broken hydrants, but when a section is shut off for any reason.

N. S. HILL, JR.: Here again we have an example of the interdependency of the various elements in design. Mr. Smith and Mr. Little brought out a point I think that in a system well-gated it may not be so necessary to have valves on the hydrants, but in a system that is not so well-gated, it is necessary, which makes the question of valves one of a local condition.

WATER SERVICE INSTALLATION[1]

By George Read[2]

At this date all domestic water connections for new subdivisions, are being installed by laying a pipe from the main to just inside the curb on the dividing line of two lots, equipped with two outlets.

Construction. On cast iron water mains, a saddle, having a 2½-inch female standard iron pipe thread, is strapped to the main. On cast iron mains from 12-inch and up, a bronze saddle is used on account of safety.

On sheet steel or iron main, a heavy coupling is electrically welded and takes the place of a saddle.

Into saddle or coupling is screwed a bronze corporation cock having a male 2½-inch standard iron pipe thread on one end and a leaded bell and outer 4-inch standard iron pipe thread on the other. The outer standard 4-inch thread is used for tapping purposes and can also be used for the laying of standard screw pipe.

Five-foot lengths of 2-inch cast iron pipe, ¼-inch thick, weighing 6½ pounds per foot, with lead prepared joints, are then run from the bell end of the corporation cock to just inside of the curb. We have tested this pipe to over 1000 pounds per square inch. The 5-foot length that ends just inside the curb, has a 2-inch standard iron pipe threaded end on which is screwed a 2-inch cast iron elbow. Into this elbow is screwed a 2-inch galvanized iron pipe riser about 20 inches long equipped with a 2 × 2 cast iron tee. This tee is equipped with bronze bushings reduced to the size of the services required at the date of installation. Bronze bushings are used on account of ease of removal, etc.

Both these outlets can gradually be enlarged up to 1½-inch without digging in the street and if both lots are acquired by one person and a large building is to be erected, the service can be made into a 2-inch.

[1] Presented before the California Section meeting, October 15, 1925.

[2] Meter and Service Superintendent, Department of Water, Los Angeles, Calif.

When tapping large trunk lines a 2-inch shut-off is placed just inside of the curb, to be used when enlarging a service; otherwise, small mains are shut off for a few minutes while making enlargement.

In new subdivisions where we are not sure of the location of driveways, a 10-foot piece of galvanized iron pipe equipped on each end with a curb cock is run both ways from the tee on the riser.

Curb cocks that are not immediately put in use, are sealed and can be used for flushing purposes, if it ever becomes necessary.

Galvanized iron or steel service pipes, already installed in streets that are to be permanently paved, are being renewed in the same manner and the Department is endeavoring to have an ordinance framed that will make it compulsory for all vacant lots to be served in advance of the paving. The cost of such installation may be included in the assessment for the street paving.

Public sentiment is in favor of all utilities being installed in advance of paving.

This method of service installation means good supply to the curb; it practically eliminates the cutting into paving for the renewing and enlarging of service pipes and it means low maintenance cost. It also means one-half the present cost to consumer, when enlarging is necessary. Its construction is identically the same as for standard cast iron water mains.

At this date we have used for service installation, 233,500 feet of this cast iron service pipe; hence, we feel as though we have passed the experimental stage.

The average cost per 2-inch cast iron service including the fittings, etc., for two supplies taken from same for $\frac{3}{4}$ and 1-inch sizes, is $34.25 each. This cost includes 10 per cent for supervision, etc.

Galvanized iron pipe is used instead of cast iron for hillsides and fills. This pipe is asphaltum painted, wrapped with burlap and repainted.

Single installations scattered over the city, are being installed with galvanized iron pipe.

Standard corporation cocks are inserted into cast iron mains up to 1-inch. Above 1-inch, saddles are used on cast iron mains and couplings electrically welded on sheet steel and iron mains of large diameters. Couplings are also electrically welded on standard screw mains carrying heavy pressures.

Pressure regulators are placed on services carrying over 125,

pounds. These regulators are placed in front of the meter, at the expense of the consumer. They are maintained by the Department, but the Department is not responsible for damages caused by their getting out of order.

Lead goose necks have been practically eliminated.

The coupling nut tail piece, formerly used for lead flanging, is now threaded, into which a street elbow is screwed and left looking downward. A short piece of pipe reaching the bottom of the excavation is then screwed into same, which is equipped with a swinging joint to connect to pipe leading away to the curb. The whole idea is to make the connection so that it will not be sprung by the settling of the earth. A fairly hard rubber gasket that will stand steam is used in connecting the coupling nut to the corporation cock.

The few leaks that we have had were not due to this method. We consider this method superior and cheaper to the lead goose neck, because when a coupling nut is screwed up tight on a lead goose neck, the lead goes on compressing due to tension, and in a short while becomes loose so that a little settling of the earth starts a leak.

Galvanized iron service pipes are laid by hydraulicking, driving or digging a ditch. The soil conditions, etc., determine the method.

A truck, carrying an air compressor equipped with paving breakers, cuts the paving in advance of the service crews. This is costing the Department 22 cents per square foot.

Services larger than 2-inch for domestic, commercial, irrigation or fire protection, are all taken from the main by either clamping or welding on a heavy coupling.

A tapping nipple is either leaded into a clamp or screwed into a coupling. A gate is placed on the tapping nipple through which the main is tapped.

Tapping machines from 1½-inch to 8-inch are made by the Department and an 8-inch service is the largest we have at this date.

Wrought iron pipe is used for irrigation services and cast iron for all other purposes.

When a fire service is installed, a tee is placed on same just inside of the curb for the domestic supply, and a gate is left controlling the fire line into the building and also a gate to control the domestic supply.

By this method the consumer is given a better supply and the Department has one less pipe to maintain in the street. The domestic service also can be enlarged by unscrewing the bushing in this tee.

We have specifications covering curb cocks, galvanized iron street elbows, couplings and elbows from ½ to 2-inch. The reason for this standardization is not only to insure good composition, galvanizing, weights, etc., but a standard dimension, so that, when a fitting has to be renewed, the space for the meter remains the same.

A special 2-inch bronze angle valve is now being used and takes the place of a regular curb cock because the keys corrode in the bodies of the curb cocks, making it very difficult and precarious at times to operate them.

This angle valve has a female thread for riser and a male thread for the meter flange. It takes the place of a street elbow, curb cock and short nipple.

We are now contemplating the use of copper pipe for sewer connections instead of the regular galvanized iron or steel which corrodes very rapidly in certain soils and conditions.

METER MAINTENANCE METHODS[1]

By J. H. Fagg[2]

This paper deals with water meter maintenance methods in the Stockton Water Department of the Pacific Gas & Electric Company, involving 11,885 services. This is a subject which is considered by us as of vital importance, for both our revenue and satisfactory public relations are dependent in a large measure on the accuracy of the meters registering the commodity we sell.

In 1920 the Stockton water system was about 20 per cent metered, which condition had existed for several years. However, the matter of water supply was becoming a serious problem, and it was finally decided that metering of all services would have to be resorted to, if the demand in the future was to be met satisfactorily.

By April, 1922 the city was placed on a 100 per cent metered basis and there followed the necessity of deciding upon a definite policy as to meter maintenance. The procedure adopted and which is now being followed is as follows:—

New meters are tested for accuracy when delivered to us, sealed, and placed in stock subject to requisition by foreman.

The meters are numbered with the Company's series of numbers and record is made of same in meter book by meter tester, which information is transferred to the meter record card system maintained in the office.

Meters in service are changed every three years, or after one complete revolution of the dial.

Meters involved in routine tests are removed and immediately tested for accuracy. The result is reported by the Testing Department to the Office where the result is posted to the meter record card and to the register, and if found to be registering more than 2 per cent fast, the consumer is refunded the amount of the overcharge.

Meters to be tested as a result of consumer's complaints of high

[1] Presented before the California Section meeting, October 15, 1925.

[2] Manager, Stockton Water Department, Pacific Gas and Electric Company, Stockton, California.

bills are either tested on location, or replaced with another meter and returned to the meter shop where it is tested in the presence of the consumer, if he so desires.

Engaged in this work are one foreman and two helpers with a small automobile for transportation, and all of their time is devoted to the maintenance of our water meters, sets and outs, etc.

The shop testing equipment consists of one Mueller Water Meter Tester complete with scales and test tank and attachment for gang testing of small meters.

During the past year 4000 meters were removed and tested and results of these tests indicate that 80 per cent were under 2 per cent fast and 4½ per cent under 2 per cent slow. The remaining 15 per cent ranged up to 5 per cent fast. These adjustments were made on consumers' bills.

The total cost to the Company to maintain this system, which includes care of sewer flushers, all sets and outs, complaints and routine changes, together with meter repair parts, is approximately $7000 per year, of which $4000 is charged to meter maintenance and $3000 to operation.

While the results of the tests on the 4000 meters in question do not seem to justify the expense, we believe that it would be difficult under any system to handle the routine work with a much smaller organization.

The damage to meters in service by hot water has not as yet been serious enough to justify considering any of the measures suggested in the way of check valves and relief valves with which you are all more or less familiar.

About 70 per cent of the meters in service are of the grease enclosed gear train type, and have given very satisfactory results.

Batteries of 2-inch meters are used where the demand exceeds the capacity of a 2-inch meter.

In conclusion, I wish to state that we are feeling our way in this matter, and we will no doubt adjust our methods from time to time as a result of more experience.

MECHANICAL EQUIPMENT FOR TRENCH EXCAVATION, PIPE LAYING, AND BACKFILLING[1]

By Thomas Brooks[2]

Previous to the World War the Bureau of Water Works and Supply of the City of Los Angeles had given very little thought to the use of mechanical equipment for the excavation of trenches, the laying of pipe and the backfilling of trenches. Up to that time there was a plentiful supply of efficient labor at wages which were reasonable from the employer's standpoint. The War however was the cause of a great change in this respect. During that interval and almost up to the present time efficient labor for trenching and pipe laying was not available, which will explain in part why the Bureau of Water Works and Supply of this City is so well equipped with mechanical apparatus for handling this class of work. Economy is another important factor worthy of consideration, as a result of the change from the old to the more modern methods.

Due to the phenomenal growth of the City of Los Angeles during the last three years, extension of our mains to supply new subdivisions being put on the market, required the installation of from 75,000 to 140,000 feet of pipe per month and in addition to the large volume of trunk-lines and betterments it became absolutely necessary, in order to meet the growing demand for water, to speed up our work in every way possible. By introducing modern mechanical equipment we were able to meet this condition satisfactorily to all concerned.

At present we have a fleet of seven pipe-trenching machines, two in the San Fernando Valley and five for the City proper. Of these, four are the "P & H" and two the "Buckeye" wheel type excavators for excavating trenches from 18 to 21 inches in width and approximately 7 feet in depth, one ladder type "Buckeye" machine for excavating trenches from 24 to 42 inches in width and 8 feet in depth.

In new tracts where there are no obstructions the small machines will dig a trench from 2500 to 3600 lineal feet in eight hours at a cost

[1] Presented before the California Section meeting, October 16, 1925.

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for operation, helper and fuel of approximately $18.00, the average depth of trench being 3½ feet. The large excavators are capable of digging a trench 42 inches in width and 5½ feet in depth and a length of from 500 to 1500 feet in eight hours at a cost, not including upkeep, depreciation or overhead, of about $25.00.

On account of the time consumed in moving the machines from job to job and the delay occasioned by break downs, the average footage of trench excavated per machine for a period of several months would be very much less than the figures above quoted. As to depreciation the oldest piece of equipment of our present fleet has been in active service for five years and I feel sure it is good for at least two years more. Four of the wheel type machines over a period of eight months dug a combined total footage of 549,446 feet of trench varying from 18 inches × 3 feet, to 21 inches × 4 feet at a cost per lineal foot, including gasoline, cylinder oil, repair material, repair labor, operator, moving expenses, and overhead of five cents. Our ladder type machine dug 100,000 lineal feet of trench ranging from 31 inchs × 4½ feet to 42 inch × 5½ feet at a total cost (depreciation not considered) of six cents per foot. The Department has a 20-ton low trailer for moving the wheel type excavators from job to job, drawn by a 5-ton capacity truck at the rate of from three to eight miles per hour.

Backfilling of trenches is done by two Holt push-blade backfillers, and two P & H trench backfillers. The Holt machines will backfill an 18 inch × 3 feet trench at the rate of from six to eight thousand lineal feet per eight-hour day. This is considered a very economic and reliable machine. For backfilling trenches, 24 inches and up, we use the P & H backfillers with or without the boom. With the boom attachment one operator can backfill from five hundred to seven hundred feet of 36 inch trench per eight-hour day. These machines are moved from job to job on one of our large trucks or on a 20-ton capacity trailer. For digging bell holes in hardpan or sandstone we have a number of pneumatic spades which are also very useful for tunneling below railway and other structures. One spade will accomplish the work of about four men with picks.

For cutting concrete pavement the Department has several pneumatic concrete breakers. This method of breaking concrete is such an improvement over the old method of gad and sledge that there is no comparison between them.

Compressed air for caulking lead joints, field riveting of sheet-

steel mains, driving the pneumatic spades, concrete breakers, cutting cement joints from cast iron pipe and for a multitude of other purposes is furnished by three Ingersoll-Rand Compressors, each having a capacity of 212 cubic feet of air per minute and mounted on 2½-ton capacity trucks.

For lowering and placing in the trench, cast iron pipe of the larger diameters (i.e., 20, 24, 30 inches and up) and for handling large valves and fittings, we are using an "O & S" Truck-Crane mounted on a 5-ton capacity truck, and after using this Crane continuously for several months, handling 24 inch Class "C" cast iron pipe, I have found it to be satisfactory in every respect and I can highly recommend a Crane of this type. We also have a smaller truck-crane for handling loads of one ton and less. For unloading pipe from cars and loading trucks at our pipe yards, the Department has one P & H and one Brownhoist Crawler tread type, 40-foot, boom crane. It would be almost impossible for the Department to handle the large tonnage of cast iron pipe received without the aid of these cranes. They have proved to be all that is claimed for them by the respective manufacturers.

For trench pumps we have one nine hundred gallon per minute centrifugal pump mounted on a four ton truck together with a generator for furnishing current to a large number of electric lights for night work. In addition to the pump and generator this truck also carries a 178 cubic foot per minute air compressor. All of the above equipment is operated by the truck motor.

For handling smaller quantities of water, four power-driven diaphragm pumps are used, mounted on small rubber tired trailers, which are good for 12,000 gallons per hour each. We also have an electric driven emergency trench pump and lighting plant mounted on a special 2½-ton capacity truck. This 800-gallon per minute pump is unique, in that it requires no suction hose, pipe or priming, it only being necessary to connect up the discharge hose, push the button and the pump does the rest, and the same time generates enough current for a large number of ninety candle power lamps. This piece of equipment was designed and assembled in the Department machine shop.

In conclusion, I would state that all repair work and overhauling is done in the Department machine shop and there is not one unit of this trenching and pipe laying equipment that is not doing its "bit" toward furnishing the people in the City of Los Angeles, the most necessary of all commodities, domestic water.

THE PUBLIC HEALTH ASPECT OF STREAM POLLUTION[1]

By J. A. Childs[2]

The contamination and pollution of stream and lakes may affect adversely the health and enjoyment of the people in a number of ways. Previous speakers have discussed the effect of stream pollution upon fish life both from the standpoint of the fish and of the sportsman, and of the effect of such pollution upon the health of live stock. I will confine my discussion to the effect of such pollution upon what may be termed the public health aspect.

First in importance is the effect of such pollution upon a water supply used for domestic purposes which may be obtained from the same lake or stream into which sewage is discharged. In Minnesota we find that approximately 92 per cent of the public water supplies are obtained from wells, and other underground sources which are not influenced by the discharge of sewage into the streams or lakes. Of the remaining 8 per cent which obtain the water from lakes and streams but a very few are so located that the water supply is materially influenced by the discharge of sewage or industrial wastes. These municipalities, with very few exceptions, have some form of water purification, either consisting of complete filtration or simply chlorine treatment by means of which the water is made safe for human consumption. Sewage treatment may in certain instances be absolutely necessary in order to prevent the gross pollution of a stream or lake which is to be used as a source of water supply. However, no engineer today would advocate sewage treatment as a substitute for water filtration for the reason that there exists on the shores near every lake or river many sources of contamination, which from the practical standpoint are beyond control. Therefore, as far as surface water supplies are concerned sewage treatment can be considered only as an aid or adjunct to the process of water purification, but not as a substitute for it.

Next in importance is the effect upon the milk supply from cattle

[1] Presented before the Minnesota Section meeting, November 14, 1924.

[2] Engineer, Division of Sanitation, Minnesota Department of Health, Minneapolis, Minn.

which are permitted to wade in sewage polluted streams where the contaminated water comes in contact with the flanks and udders of the cows. At the present time only a portion of the milk which is supplied to our larger municipalities is subjected to pasteurization. It can readily be seen, therefore, that permitting cattle to wade in the water of sewage polluted streams may be a source of real danger to the people who are dependent upon the milk supply. In order to entirely eliminate this danger so far as sewage from municipalities and institutions is concerned, it would be necessary to do one of three things: to pasteurize all milk used for human consumption; to construct fences which would absolutely prevent cattle having access to the water in these lakes and streams; or to treat and disinfect all sewage before being discharged. Here, as in the case of public water supplies, we are confronted with the fact that even though all the sewage from municipalities and institutions were treated to a high degree, including disinfection, there would still remain many sources of contamination which from a practical standpoint could not be controlled, and while complete sewage treatment would possibly lessen this danger, it would not eliminate it.

The possible danger of bathers contracting diseases when bathing in water contaminated with sewage must also be considered. It must be admitted that there is a possibility of bathers contracting certain diseases from bathing in water contaminated with sewage. Tangible evidence in the form of reliable statistics as to the degree of danger to which the bather is subjected is apparently lacking, yet it would be acting upon the side of safety to require that no sewage be discharged onto or in the vicinity of bathing beaches which has not first been clarified and thoroughly disinfected.

Ice may be classified as a form of water supply, since it is quite generally used during the summer months for the cooling of beverages. It will be of interest to know that ice in forming crystallizes and squeezes out a large proportion of chemical and bacterial impurities which are normally present in the water from which it is formed. Consequently, where the water in the pond, lake or river from which the ice is cut is of sufficient depth so that there will remain a layer of water below the ice, and where the sewer outlet is submerged so that the sewage cannot actually flow over the surface of the ice, there is no great danger of the ice being an agent in the transmission of diseases even though the water from which it is formed is polluted with sewage. There is no case on record, which is not open to

question, of an epidemic of typhoid fever having been caused by the use of ice. Therefore we find that stream pollution is of very little sanitary significance as far as ice supplies are concerned.

The question as to what extent public health is affected by nuisances due to stream pollution alone, other factors being disregarded, may be of interest. It must be admitted that nuisances have debilitating and nauseating effects upon some individuals tending possibly to an impairment of their general health which may lower to some extent their natural resistance to communicable diseases. A grossly polluted and offensive stream, especially where the pollution is so heavy that there is floating sludge or scum, may attract flies, and might under these conditions actually be a source of danger in case these flies later come in contact with human food. Examples of such gross pollution are fortunately seldom met with in Minnesota and where these conditions do now exist the municipalities are taking remedial measures. Public decency alone demands the elimination of nuisances, but vile and offensive as a nuisance due to stream pollution may become, there seems to be very little danger of any of these odors being the direct cause of any communicable disease.

It is a recognized fact that sewerage systems are today considered as public health necessities. All such systems must have outlets, the sewage finally reaching some lake or river. The cost of completely treating and disinfecting sewage, including interest and depreciation changes and operating expenses, is from $1.50 to $3.00 per capita per year, depending upon local conditions. There should be some tangible reason in each case for requiring sewage treatment before a municipality or institution is put to the great cost of installing and operating a sewage treatment plant.

It would seem that there is need at the present time for a careful study of the streams and lakes of Minnesota in order to determine the relative economic value of the various waters of the State. Such a study might lead to certain general classifications of the lakes and streams depending upon the uses to which they are put. It should not be difficult to establish certain fairly well-defined standards for each class of stream or lake as regards the degree of contamination or pollution to be permitted. The municipalities and industries using the streams and lakes for sewage and industrial waste disposal would then be enabled to proceed intelligently with the installation of whatever treatment works might be necessary to meet the requirements of the particular classification.

RAPID FINE SAND FILTRATION

By Hiram W. Blaisdell[1]

The filtration of municipal water supplies from rivers of medium turbidity, subject to occasional flood turbidities as high as 300 p.p.m., without settling; river water of medium turbidity, subject to occasional excessive flood turbidities that can be settled, with or without the use of alum; and water of low turbidity such as that of the Great Lakes and their connecting rivers, and storage waters of all classes, can be successfully accomplished at a 25 to 50 m.g.a.d. rate by the combined use of *fine sand, reverse flow and filter washer.*

FILTER SAND

	EFFECTIVE SIZE	COEFFICIENT UNIFORMITY	60% PASS	PER CENT PASSING 80 MESH	PER CENT PASSING 100 MESH
	mm.		mm.		
Yuma Filter	0.21	2.2	0.46	8.0	3.0
Delaware River "Bar" Philadelphia, Pa.	0.22	1.9	0.42	7.1	0.9
Lake Ontario (Kodak) Rochester, N. Y.	0.18	1.5	0.27	10.0	3.0
Arundel "Asphalt" Baltimore, Md.	0.11	3.9	0.43	27.1	25.0

The Yuma grade of sand, which has been in use for twenty years, will give a filtrate of practically zero turbidity from easily clarified waters, while the Delaware River "Bar" sand, will give equally satisfactory results from waters more difficult to treat. The Lake Ontario (Kodak) sand, from the Lake Ontario Sand Company, Charlotte, N. Y., and the special "Asphalt" sand, from the Arundel Sand & Gravel Co. of Baltimore, Md., will reduce the turbidity of water of the Baltimore and Annapolis, Maryland class, which carry an almost unsettleable clay, to 1 to 2 p.p.m. All tests thus far made give equally good results at 25 and 50 m.g.a.d. rates of flow.

[1] Filtration Engineer, President H. W. Blaisdell, Filtration Company, Philadelphia, Pa.

With the above filtering medium, cleaned under water with a filter washer, through which the entrained air will be removed, the finer grains of sand washed into the interstices between the coarser, thereby reducing its bulk about 5 per cent, and a thin layer of very fine sand left on the surface after washing, the filtrate will be of practically zero turbidity, at a 50 m.g.a.d. rate of flow with an easily clarified water and two at a 25 m.g.a.d. rate with more difficult water, regardless of the turbidity of the applied water.

The efficiency of a rapid fine sand filter does not depend upon the *schmutzdecke*, or bacterial action of the slow sand, but upon the very fine surface sand, about one-eighth of an inch in thickness, left after washing, which, when dried, has a velvet-like feeling, and is so fine that the process of filtration resembles that of porous tube, or plate filters, the whole surface being equivalent, in its action, to a great porous plate filter.

FILTERING CAPACITY OF DRY, WET OR WASHER CONSOLIDATED SAND

Although the writer has been engaged in the construction and operation of rapid find sand filters for twenty years, on Colorado river water, in the desert country of Arizona and South Eastern California, it was not until the spring of 1921, when engaged in making tests for a filter, of the above type, for the Eastman Kodak Company, Rochester, New York, that the discovery was made of the difference in the filtering qualities of sand placed in a filter in a dry, or wet condition and the necessity of using a filter washer to remove the entrained air and consolidate, under water, the sand put into a filter in a wet condition.

A galvanized iron test filter 18 inches diameter by 10 feet deep had been installed and the first charge was dry sand of an analysis similar to the above. Successful clarification tests were made with this sand, at 25 m.g.a.d. rate of flow, until a few inches of gas-house coke was added to the surface, with a view of lengthening the runs, with the result that the solubles in the coke permeated the sand and destroyed its filtering qualities. The charge was removed and replaced with one of sand from the same source, which, owing to rains, was quite wet, no thought being given to this condition. When tested the clarification results were unsatisfactory at even 6 m.g.a.d. rate. This was puzzling, for a 1 inch glass tube filter, charged with dry sand, from the same source, gave satisfactory results. This charge was then removed and replaced with one of wet, very fine

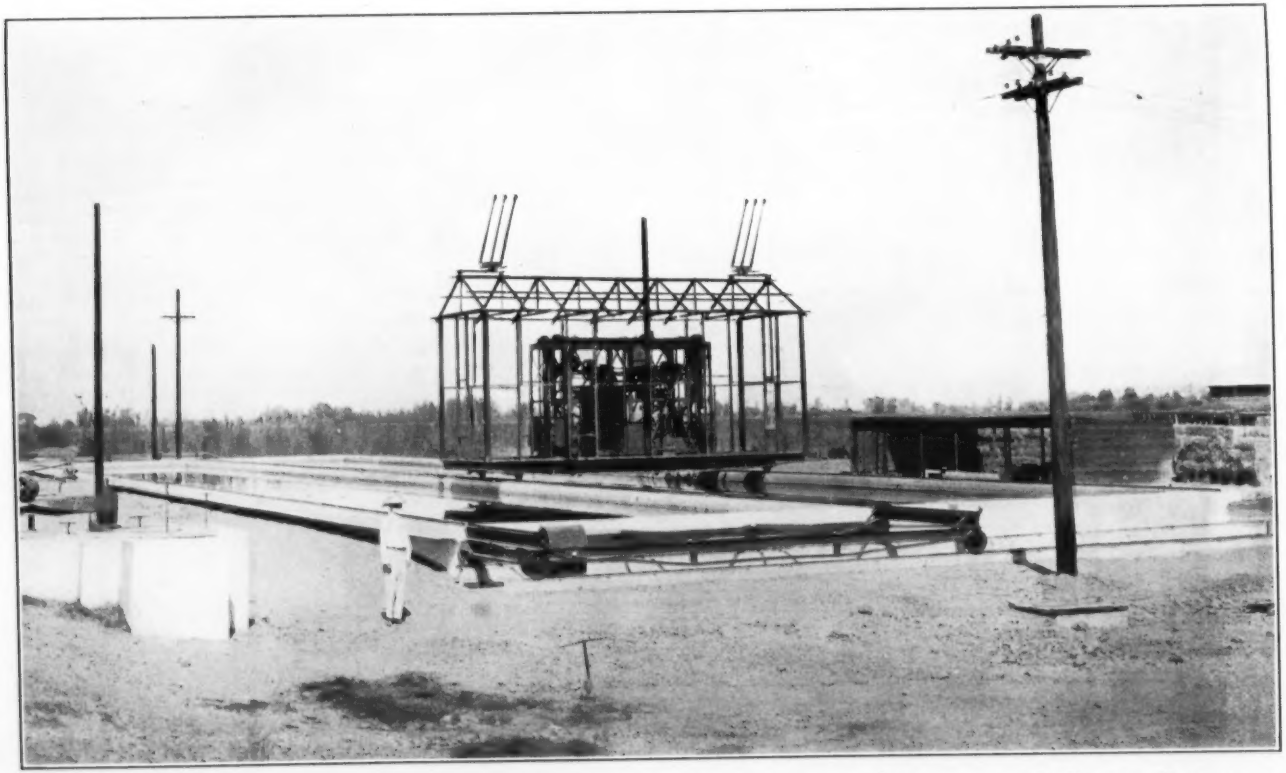

FIG. 1. TYPICAL UNCOVERED RAPID FINE SAND FILTERS, WITH 12-FOOT BLAISDELL WASHER, AT EL CENTRO, CALIFORNIA

Two basins 24 feet by 200 feet filtering area 0.2 acre. Successfully operated at 37.5 m.g.d. rate, an output of 7.5 m.g.d., on water of 30 to 40 p.p.m. turbidity.

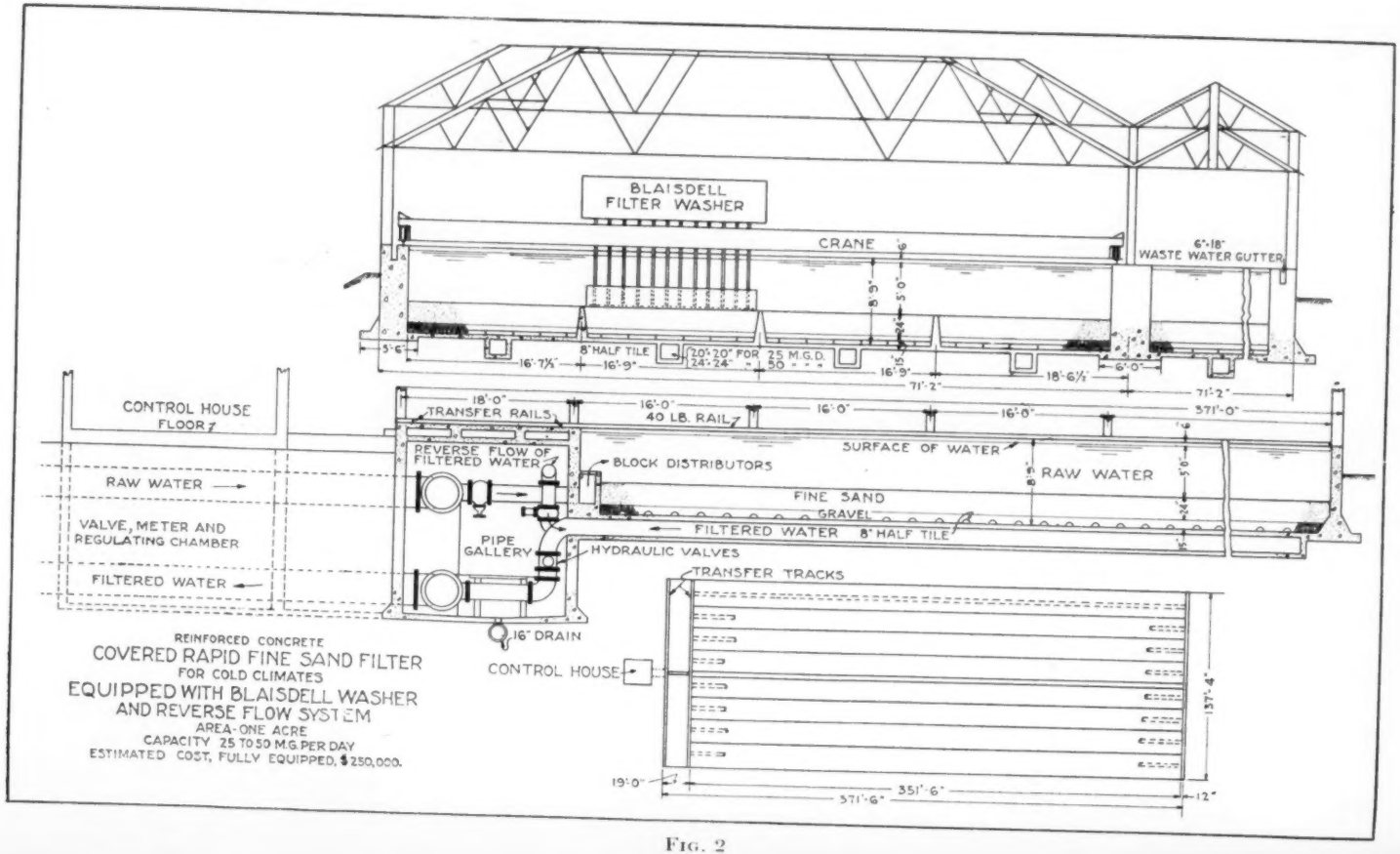
BLAISDELL
FILTER WASHER
CRANE
6'-18"
WASTE WATER GUTTER
8'-9"
5'-0"
5'-6"
8" HALF TILE
20'-20" FOR 25 M.G.D.
24'-24" " 50 " "
16'-7½"
16'-9"
16'-9"
18'-6½"
6'-0"
71'-2"
71'-2"
CONTROL HOUSE
FLOOR
18'-0"
TRANSFER RAILS
16'-0"
40 LB. RAIL
16'-0"
16'-0"
371'-0"
REVERSE FLOW OF
FILTERED WATER
BLOCK DISTRIBUTORS
SURFACE OF WATER
8'-9"
RAW WATER
5'-0"
RAW WATER
FINE SAND
GRAVEL
24"
VALVE, METER AND
REGULATING CHAMBER
FILTERED WATER
8" HALF TILE
PIPE
GALLERY
HYDRAULIC VALVES
TRANSFER TRACKS
FILTERED WATER
16" DRAIN
CONTROL HOUSE
137'-4"
19'-0"
351'-6"
371'-6"
12"
REINFORCED CONCRETE
COVERED RAPID FINE SAND FILTER
FOR COLD CLIMATES
EQUIPPED WITH BLAISDELL WASHER
AND REVERSE FLOW SYSTEM
AREA-ONE ACRE
CAPACITY 25 TO 50 M.G. PER DAY
ESTIMATED COST, FULLY EQUIPPED, $250,000.

FIG. 2

Lake Ontario sand, of which 10 per cent would pass an 80-mesh screen, with but little better results, although a 1 inch glass tube filter, charged with the same sand, dried, gave satisfactory results at 50 m.g.a.d. rate. It then occurred to the writer that his previous

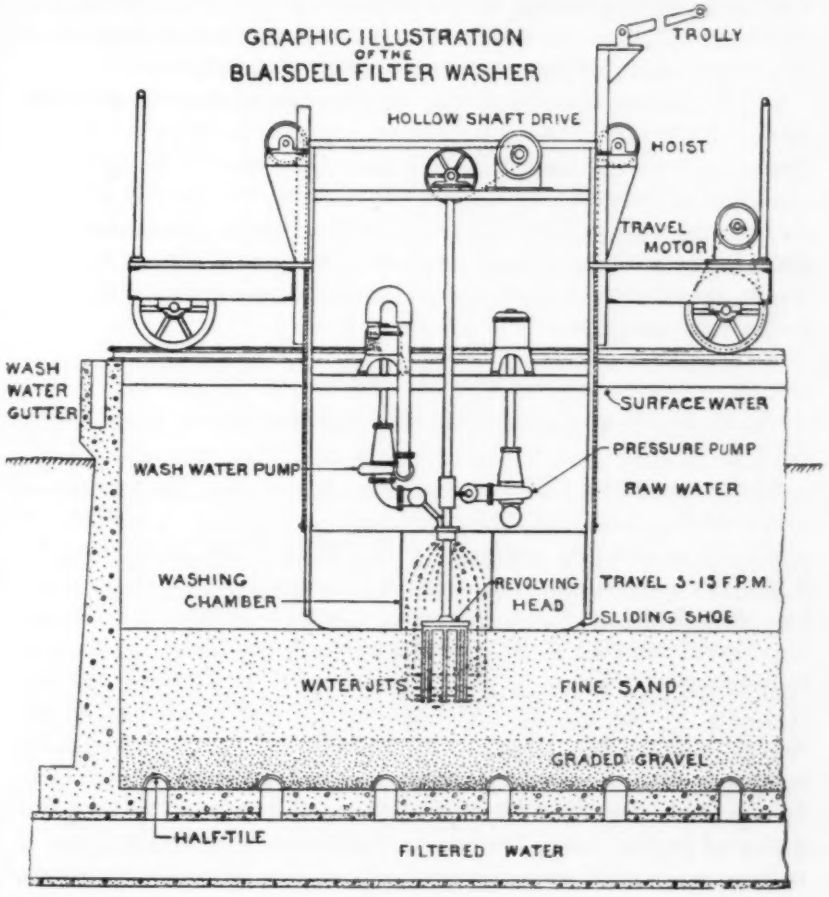

FIG. 3

work had been on dry sand, so the charge was removed, dried and returned and when tested gave satisfactory results at 50 m.g.a.d. rate.

The charge was again removed, thoroughly mixed and returned to the filter in its wet condition and washed into place, under water, with an improvised filter washer and on testing gave as satisfactory results as the dry sand. This appears to prove that to operate a

filter, at high rates of flow, the sand must be either dry, when put into the filter, or consolidated in place by agitation under water, with a filter washer. The explanation of this is that, in a dry condition, the finer grains naturally occupy the interstices between the coarser, but when wet; surface tension or the adhesion of the grains to one another prevents their normal distribution and results in a segregation of grains disadvantageous to the efficiency of the filter.

This is probably the reason why the filtration of water through fine sand, at high rates of flow, has not been a success in the past. It may also account for the present limited rates of flow used in the operation of slow sand filters for, *by removing the entrained air and consolidating the sand under water, with a filter washer, the rates of flow of slow sand filters can be more than doubled, with satisfactory turbidity and bacterial results*, provided the underdrains and conduits have sufficient capacity for the increased flow.

REVERSE FLOW

The reverse flow treatment, for renewing the filtering qualities of a partially clogged filter, consists in a flow of filtered water through the collecting conduits, half-tile sub-drains, gravel and fine sand, at a rate of 15 m.g.d. or $\frac{3}{8}$-inch rise per minute for 5 to 15 minutes daily, or oftener if required, as compared with a 24-inch rise per minute, for 3 minutes, required for a mechanical filter wash, which restores the loss of head, due to clogging, to nearly that of a freshly washed filter. An observation glass in the side of an 18-inch test filter, disclosed no movement, or change in the surface sand, or increase in the turbidity in the water over the same. The escape of a few fine air bubbles due, possibly, to the fact that the filter had been operated under a negative head, was all that was to be seen. It is possible that the upward flow of water, between the very fine grains of surface sand, breaks the clogging matter attached to, or resting on the sand, into innumerable particles, corresponding in size to that of the grains of sand, which are possibly partially turned up on edge, for the continued operation of the reverse flow lengthens the runs between treatments, as shown by the following Montreal experiment. This may indicate that the accumulation of broken, clogging material acts as a pre-filter for the fine sand, thereby lengthening the runs. The reverse flow is similar to that of "cracking" a mechanical filter, to lengthen the runs, especially when algae shortens the runs.

Comparative cost of operation and efficiency of slow sand and mechanical filters

There is probably no better place, in the United States, for a comparison of the cost of operating and efficiency of slow sand and mechanical filter plants, than at Wilmington, Delaware, where there is one of each, operating at approximately the same capacity, the water for both coming from the same source of supply. The slow sand has been in operation 15 years, during which time it has been cleaned with a filter washer. The following data have been compiled from the Water Commissioner's report for the year 1922–23.

FILTER	OUTPUT FILTERED WATER	WASH WATER USED	OPERATING EXPENSE PER M.G. NET YIELD	AVERAGE FOR 3 YEARS				
				Bacterial efficiency without liquid chlorine treatment	B. coli removed by filter	Bacterial efficiency effluent after liquid chlorine treatment	Turbidity removed	Color removed
	mg.	*per cent*		*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Slow sand	2,555	0.111	$2,428	98.51	97.04	99.81	99.76†	60.29
Mechanical	2,576	2.22	5,343	83.95	2.23*	99.54	100.00	60.00
Montreal slow				97.00		11 m.g.a.d. rate of flow		
Sand filters			$0.17	92.80	30.00	22 m.g.a.d. rate of flow		

* As the removal of B. coli., by the mechanical filters, was but 6.50 per cent, 0.53 per cent and 0 during the three years, the consulting bacteriologist suggests that: "As the efficiency of a mechanical filter depends entirely on the chemicals used, that liquid chlorine apparatus be installed so that a portion of the liquid chlorine be added to the water as it enters the coagulating basin."

† 100 per cent except when settled water is by-passed because of air-bound filters, which would not have occurred had they been constructed for the use of the reverse flow.

Alum used in operation of filter plants

Slow sand	None
Mechanical in grains per gallon	0.88
Mechanical in tons per day	0.45
Mechanical in tons per year	165.06

Attention is called to the above record which shows that the slow sand filters removed 97.04 per cent of the B. coli as compared with a removal of but 2.23 per cent by the mechanical filters.

To make the reverse flow treatment a success, the flow of 15 m.g.a.d. must be distributed so evenly, under the filter sand, that there will be practically no difference in the upward pressure, otherwise it will lift and boil the sand at points of greatest pressure. Eight inch

half-tile subdrains, laid on 2½-feet centers and the joints cemented so that all the water will pass out under their edges, should be used for 12-foot filter bays. It may be advisable to use concrete half-tile, with lugs under their lower edges, to aid in the even distribution of the reverse flow water. To relieve the packed, or hardened condition which sometimes occurs in a filter bed, provision is made for a reverse flow of sufficient volume to "lift" the sand, for a fraction of a minute, which will relieve the "pack."

NO LOSS OF WATER IN USING THE REVERSE FLOW

The amount of filtered water required for a daily reverse flow treatment, at a 15 m.g.a.d. rate, for 15 minutes, is 156,250 gallons per acre, which, when a filter is being operated at a 25 m.g.d. rate, is a little over $\frac{6}{10}$ *of 1 per cent of the water filtered. This water is not lost,* for it is mixed with that in the basin over the filter sand, and is re-filtered. *Any number of reverse flows can be applied daily without the the loss of water.*

COMPARATIVE LOSS OF WATER IN CLEANING RAPID FINE SAND AND MECHANICAL FILTERS

The amount of *unfiltered water* required to operate a filter washer, in connection with the reverse flow, is *approximately one gallon per square foot of filter surface cleaned, or 43,560 gallons per acre. If a filter is cleaned once a week, when being operated at a 25 m.g.a.d. rate, the unfiltered water wasted, is* $\frac{1}{40}$ *of 1 per cent of the water filtered, whereas the average mechanical filter wastes 2½ per cent, or 100 times as much, of filtered water.* The importance of these facts can hardly be over-estimated, for they offer a new field of investigation in the reduction of water wasted in the process of filtration.

MONTREAL TEST FILTERS[3]

The results that can be obtained from filters, properly designed for the use of the reverse flow and filter washer, operated at a 25 to 50

[3] Compiled from 21 prints of "The Montreal Water Board Filtration Works, Blaisdell Reverse Flow Filtration Tests." All drawings numbered 322 and dated November 14, 1921 and one of same drawing number, dated September 21, 1921, each drawing giving the daily record, for a month, of each filter being tested. They were prepared by Frederick E. Field, Division Engineer and signed by him, as well as by C. Des Baillets, Chief Engineer.

m.g.a.d. rate, are indicated by the following experiments, made by the Water Department of the City of Montreal, under the direction of the writer, during the months of July, August, September, October and November, 1921.

Two test filters, 18 inches diameter by 10 feet deep, were constructed of galvanized iron, with an observation glass 4 by 12 inches high, in each, half of the glass below the surface of the sand and half above, and hand holes for removing the sand. The filters were set on a wooden stand 2 feet high, in order to make available a total positive and negative loss of head of 10 feet. Ball and cock valves kept the water in the tanks at a constant level. To determine the loss of head, glass tubes were connected by rubber pipes with the filtered water discharge pipes at their lowest points below the filters and extended up above the water in the filters and tape lines, with zero at the water level, were hung by the sides of the glass tubes. Needle valves regulated the flow, which was measured by discharging into quart jars which were to fill in a specified number of seconds. Readings of the loss of head were recorded hourly, also the date and hour of the reverse flow treatments and recovery of loss of head effected by the same. The engineer in charge of the pumping station attended to this work.

No. 1 test filter was charged with 27 inches of sand from the Montreal 6 acre slow sand filters, and No. 2 with 27 inches of the same sand, on which was placed 6 inches of fine sand, similar to that in use at Yuma. The sand in both filters was washed into place and the entrained air removed by an improvised filter washer.

The two filters were put into commission July 13 on St. Lawrence River water, of an average turbidity of 21.8 p.p.m. and rate of flow of 24 m.g.a.d., during the five months they were in operation. The initial loss of head of No. 1 was 12 inches and No. 2, 24 inches. No. 1 ran 10 days before the positive and negative loss of head amounted to 9 feet, while No. 2, due to its 6 inches of fine sand, lost 9 feet in 30 hours. A reverse flow given No. 1, of 14.7 m.g.a.d. of filtered water for 15 minutes, reduced its loss of head to 12 inches, the same as its initial loss, while the same treatment of No. 2 reduced its loss to 8 inches, only one-third of its initial loss. The length of runs gradually increased until October 23, when No. 1 completed a run of 12 days and No. 2, 10, on water of an average turbidity of 13. These long runs were made following the test run of five days, on water of an average turbidity of 92 p.p.m., referred to below.

On October 3, the turbidity of the water applied to the two filters was increased to an average of 92 p.p.m., for five days. The rate of flow continued at 24 m.g.a.d., which made it necessary to give No. 1 a reverse flow daily and No. 2 three, or four a day. The turbidity of filtrate from No. 1 was less than 2, for four days and 4 for one day, while that from No. 2 was less than 2, for the five days, which indicates that fine sand is required to successfully treat water carrying a turbidity of 92 p.p.m., at a 24 m.g.a.d. rate of flow. With the exception of the one day, referred to above, the filtrates were less than 2, during all of the tests.

The test run of No. 1 was discontinued November 30, when the loss of head, after a reverse flow, was 6 feet, a continuous run, without cleaning, of 141 days, during which 24 reverse flows were applied, an average of one every 5.9 days.

The test run of No. 2 was discontinued on November 2, when the loss of head, after a reverse flow, was 6½ feet, a continuous run, without cleaning, of 111 days, during which 54 reverse flows were applied, an average of one every 2.1 days.

From November 2 to 19, 17 days, No. 2, *without cleaning, was operated at a 48 m.g.a.d. rate,* on water of 13 turbidity, the filtrate from which was less than 2. On the 19th the loss of head, after a reverse flow, was 8.2 feet. During the run 13 reverse flows were applied, an average of one every 1.3 days.

Reduced to filter operating terms:

The output of filtered water from No. 1, *for 140 days, without cleaning, was at the rate of 3384 million gallons per acre,* and that of No. 2, *for 129 days 3456 million gallons.*

The importance of the reverse flow is evident from the fact that the *outputof the above test filters, between cleanings, was ten to twenty times that of slow sand filters,* when operating on water of the same turbidity. Such long runs are not advisable, in practice, but are possible in case of an emergency.

MONTREAL SLOW SAND FILTER TESTS

Filters No. 2 and 13, of the Montreal 6 acre slow sand filtration plant, with an area of ⅜ acre each, were operated for nearly three months during the summer of 1921, on St. Lawrence River water, of an average turbidity of 12.7 p.p.m., at an average rate of flow of 11 and 22 m.g.a.d. respectively, without the use of alum. Both were given reverse flows and cleaned with a filter washer. No. 2 was

given three reverse flows and seven cleanings, and No. 13 five reverse flows and 14 cleanings, the number of reverse flows being nearly proportional to the rates of flow. The filtrate from both was less than 2, at all times and the bacterial removal, without the use of chlorine, 97 per cent from No. 2 and 92.8 per cent from No. 13. The filtering medium was 27 inches of sand, similar to that in use in the slow sand filters of Philadelphia and Pittsburgh, Pennsylvania.

As shown by the operation of the two test filters, previously described, the above filters could have been satisfactorily operated, at a 24 m.g.a.d. rate, for two or three months, without washing, had the sub-drains and conduits been of sufficient size and the use of the reverse flow. This would have given the *six acre filter plant an output of 150 m.g.d. instead of the present 50 m.g.d. If they had been constructed for the use of the rapid fine sand process the output would have have been 300 m.g.d.* This output could probably have been obtained at not over 20 per cent increase over the first cost.

REMOVAL OF TASTE, ODOR AND COLOR

The rapid fine sand filters at Yuma, Arizona, Calexico and El Centro, California, and of the Eastman Kodak Company have proved efficient in the removal of taste, odor and color.

CONSTRUCTION

In a rapid fine sand filtration plant, the main outlet and reverse flow valves should be hydraulically operated, as in a mechanical plant, for the main valve must be closed while a filter is being cleaned or treated with the reverse flow.

The width of filter bays in both open and covered filters of an area of one acre, or more, is 63 feet 6 inches divided into five 12 foot 6 inch units by thin longitudinal concrete walls extending from the floor to the surface of the sand, which allows the cleaning of one unit without interfering with the use of the others. The open filter is so designed that it can be subsequently covered with a gypsum-steel roof, for protection from frost, at practically the same cost as if constructed with the filter.

A 24 by 90-foot filter is used for an output of 1 m.g.d. at a 24 m.g.a.d. rate of flow and multiples of this for larger requirements.

Open, rapid fine sand filters can be operated in colder climates than slow sand for, when being operated at a 25 m.g.a.d. rate, a downward

flow of $\frac{5}{8}$ inch per minute, the water passing down through the filter in 24 hours is equal, in volume, to a column 76.73 feet in height over the surface. The contents of a filter basin, with a 5-foot depth of water, would be changed every 1.6 hours, or 15.3 times each day. It will be difficult for solid ice to form under these conditions. If a few inches of ice should form, it can be broken and moved out of the way of the washer.

COST OF CONSTRUCTION

The cost of constructing a rapid fine sand filter, of an area of one, or more acres, with a capacity of 25 m.g.a.d., in a climate where a roof, to prevent freezing, is not required, completely equipped with piping, valves and filter washing machine, will not exceed $6000 per m.g.d. capacity. Where a roof is required the cost will be about $10,000. At a 50 m.g.a.d. rate, which is feasible with water of low turbidity, the cost will be $3000 and $5000 per m.g.d.

Rapid fine sand filters have a large overload or emergency capacity and it is not necessary to provide filtered water storage basins, for the pumps can take water from a sump, or well, about 15 feet in depth below the surface of the water in the filters, into which the filtered water main should reach nearly to the bottom, which will give a positive and negative head of 15 feet, about 10 feet of which, plus the loss of head due to friction of water in passing through the filter sand, is used. The Yuma rapid fine sand filter plant has three 24 by 90 feet filters, which discharge into a common sump, with no intervening flow regulating devices, the pump drawing from the sump. In the Calexico and El Centro rapid fine sand filter plants, the first with two 24-by 160-foot basins and the latter with two 24- by 200-foot, the discharge pipes are connected direct to the pumps. The El Centro filters, which have a net filtering area of two-tenths of an acre, *have been successfully operated at a 37.5 m.g.a.d. rate*, this being the maximum capacity of all of the pumps, on water of an average turbidity of 30 to 40 p.p.m. Settling basins are used in connection with the operation of the filter plants on Colorado River water.

The Eastman Kodak Company three-quarter acre rapid fine sand filter plant, on Lake Ontario, about 12 miles north of Rochester, New York, with eight 16½- by 250-foot filter bays, has no filtered water basin at the plant, the pumps drawing their supply from a filtered water sump. The filters are normally operated under a positive and negative head of 5 to 10 feet, which can be increased to 15 feet.

The usual output of filtered water is 9 m.g.d. which is a 12 m.g.a.d. rate on the $\frac{3}{4}$ acre of filters. Each filter has a flow regulating device. The plant has been in operation for over three years on Lake water of 4 to 300 p.p.m. turbidity, the latter being due to an occasional admixture of flood water from the Genesee River. The average turbidity is 8 p.p.m. The filtrate has always been of the highest quality and satisfactory for the exacting requirements of photographic work, regardless of the rate of flow, or turbidity of the raw water, without the use of alum. The plant was designed for a 12 m.g.a.d. rate of flow, but has been operated at 16 m.g.a.d. rate, with satisfactory results. The sand, which was dredged from the Lake, is finer than was desired, 10 per cent passing an 80-mesh screen, whereas tests showed that a sand with 5 per cent would do the work, but the coarser sand was not available.

FILTER WASHER

The writer includes a description of his filter washer, which was used in the foregoing described experiments, as the success of rapid fine sand filtration depends upon the use of such a machine, for washing.

The Blaisdell crane type of filter washer, which has been in successful use for twenty years consists, essentially, of an inverted steel box, or washing chamber, 24 inches high by 24 inches wide and lengths of 6 and 12 feet, with sliding shoes attached to the lower front and rear edges, which form a water seal, also allow the sliding of the chamber on the surface of the filter sand when in operation. Vertical, hollow driving shafts extend from the operating mechanism down through the top of the box, or chamber, to a head with pipe arms and teeth which extend from 8 to 14 inches down into the sand. The pipe teeth are on a diameter of 12 to 18 inches. There are a number of $\frac{3}{32}$-inch holes near the lower ends of the teeth. A sufficient number of washing units are installed to clean the sand under the entire length of the chamber, which has no bottom. The chamber is carried by a steel crane bridge, with speeds of 10 to 20 feet per minute. Provision is made for raising the chamber and a transfer apparatus is incorporated in the crane bridge by means of which the washing machine can be moved on transverse tracks, from one filter bay to another. In cleaning a 63-foot-6-inch filter bay the 12-foot washing unit is moved longitudinally on its supporting crane bridge, as each unit is cleaned. The wash water is dis-

charged into a pipe on the bridge which discharges into a gutter in the top of each alternate longitudinal wall between the filter bays.

In practice, the chamber is lowered into the water over the filter sand, pressure and suction pumps are started, the former taking unfiltered water from above the sand and forcing it down through the vertical hollow driving shafts, out through the pipe arms, down through the ½-inch pipe teeth and out through the holes near the lower ends of the same. The hollow shafts make 40 to 50 r.p.m. The chamber is then lowered onto the surface of the sand, which the revolving pipe teeth and water jets thoroughly clean as the apparatus is moved forward 10 to 20 feet per minute, the latter speed being used for washing to a depth of 8 inches. The dirty wash water rises into the chamber, from which it is drawn by a centrifugal pump and discharged into a wash water gutter. Occasionally two 14-inch teeth are substituted for 8-inch for two washings, to remove impurities that may have passed through the upper 8 inches of sand. No sand is wasted.

To insure long life, low cost of up-keep and maximum efficiency in operating, the filter washer is made of high-grade material, the various parts being designed to provide for easy replacement.

By the use of one of these filter washers, with a 12 foot length of chamber and 60 k.w. hours, one man will clean an acre filter 8 inches deep in four hours. The cost of cleaning the 6-acre Montreal slow sand filters is 17 cents per million gallons filtered. One man, with a 16-foot washer, does the work. The output of filtered water is approximately 50 m.g.d.

The filter plants at Yuma, Calexico, El Centro, Wilmington, Eastman Kodak Company and Montreal, Canada, were constructed for the use of the Blaisdell filter washer.

AERATION OF FILTER SAND

It is possible that by forcing air, instead of water, through the revolving washer teeth, into a rapid fine sand filter, covered with a few inches of water, combined with the scouring action of the teeth not only to keep the grains of sand free from the gelatinous growth, which often gives trouble in the operation of mechanical filters, but so to oxidize such growth that it will not impede filtration. Thus far the scouring action of the teeth has kept the grains of sand free from all growths and incrustations.

It is also possible that, in thus aerating the sand, a rapid fine sand filter can be successfully used to remove manganese from water, for the experiments described by John R. Baylis[4] seem to indicate that a filter, with clean sand, would be effective in the removal of manganese, if subject to exposure to air, by draining, a few hours each week. The scouring action of the washer teeth and a daily treatment with air may produce beneficial results.

SUMMARY

When rapid fine sand filtration is more generally understood its use should increase, for the cost of installation and operation are less than one-half that of any filter now in use. Its operation is so simple that a mechanic can operate it, no chemist being required for small plants. Its flexibility is an important feature, for the rate of flow can be instantly increased from a minimum to maximum without impairing its efficiency.

Thus far no water has been found that could not be successfully filtered without the use of alum. The problem is simply that of selecting a sand which, screened to 20-mesh, has a sufficient percentage of fines to accomplish the desired result, but not too fine, for the finer the sand the more frequent will the reverse flows and washings be required.

No filtered water is required in washing, the raw water used for this purpose being $\frac{1}{40}$ of 1 per cent of the water filtered.

A rate of flow of 25 to 50 m.g.a.d. is practical, without settling, with water of medium turbidity, subject to occasional flood turbidities of 300 p.p.m.

The waters of the Great Lakes and connecting rivers, St. Lawrence, Ottawa and rivers of this class and storage basin waters of low turbidity, of the Boston and New York class, can be successfully filtered at a 50 m.g.a.d. rate of flow.

A high percentage of removal of bacteria, turbidity, and color is effected, without the use of alum, as shown by a comparison of the Montreal and Wilmington filtration records.

APPENDIX

A simple and convenient method of determining the filtering quality of sand, for use in rapid fine sand filters, is as follows:

[4] JOURNAL, October, 1924, page 231.

thoroughly wash a few pounds in filtered water, care being taken, in decanting the wash water, not to waste the very fine grains. Dry and screen to 20 mesh. Take a 1½-inch O. D. glass tube, five or six feet in length, and paste a strip of paper, graduated to $\frac{5}{8}$-inch units, on the tube from the upper end down 15 inches. Press a rubber cork in which there is a $\frac{3}{16}$-inch brass pipe 3 inches in length, tightly into the lower end of the glass tube. Construct a screen of graded sand over the cork and brass tube, with four ½-inch layers of 4- 10- 20- and 30-mesh sand to prevent filter sand passing through the brass pipe. Connect the brass pipe with a glass *T* by tightly fitting rubber tubing. Place pieces of rubber tubing, about 4 inches long on the two ends of the glass *T*, on one of which place two screw clamps and one on the other. Close the single clamp and leave the other two open. Mark the glass tube for a depth of 24 inches of sand. Fill the tube rapidly with dry filter sand to a depth of 24 inches, care being taken to keep the funnel full of sand and the tube vertical so that flow will be regular and no sizing caused by the sand sliding on the inner surface of the tube.

Support the tube by a laboratory clamp stand. Connect the rubber tubing with the two clamps with a glass tube in a rubber stopper in the top of a carraf, to prevent floor dust contaminating the filtered water. Fill the filter tube rapidly with distilled, or filtered water and keep it full until the filter sand is washed clean, as will be shown when the filtrate has the same turbidity as the applied water. When the sand is clean cease adding water and allow that in the tube to drain down to a depth of 4 inches above the sand when the inner of the two clamps should be closed. Fill the tube with the water to be filtered and open the clamp sufficiently to allow enough water to pass to cause a drop of $\frac{5}{8}$ inch per minute, in the surface of the water in the tube, which represents a rate of flow of 24 m.g.a.d. The turbidity of the filtrate can be determined by various methods,—that designed and used by John R. Baylis, being very simple and accurate, for a turbidity as low as $\frac{1}{10}$ of 1 p.p.m. can be determined.

By using a sand of the requisite fineness, for the water to be tested, the turbidity of the filtrate will be practically zero, except with waters of the Baltimore, Md. class, which are very difficult to clarify. For these waters it is necessary to use the finest sand and to connect the rubber tube on the glass *T*, on which there is one screw clamp, with a pipe from a filtered water main or tank with sufficient head to "Lift" the filter sand in the glass tube through which

some of the very fine sand will be separated and deposited on the surface of the filter when the reverse flow is discontinued. A cork in the upper end of the glass tube with a *T* pipe connected with rubber tubing will take care of the overflow. Care should be taken not to use a reverse flow of such volume as to waste the very fine sand through the overflow. The result of the reverse flow will be a filter surface closely resembling that obtained in the practical operation of the filter washing machine. The use of this method of securing a thin layer of very fine sand, on the surface of a glass tube filter, gave a filtrate from untreated Baltimore City water with a turbidity 33 per cent lower than was obtained before the reverse flow treatment.

A thick wall glass tube filter can be constructed for five dollars and, if a laboratory is not available, tested in an office by suspending from an electrolier by picture cord wires, care being taken to pass the wires down opposite sides of the tube to and around the brass outlet pipe at the bottom to keep the cork in place.

With such a filter, charged with suitable sand for the water to be tested, almost unbelievably high rates of flow of well clarified water can be obtained. A test made by the writer, some ten years ago, with such a filter, at Sacramento, California, on settled Sacramento River water, then being used by the city, gave a well clarified filtrate at 140 m.g.a.d. rate of flow.

A trial of such a filter will convince the most skeptical that there are latent possibilities in rapid fine sand filtration.

Mr. Baylis has had a 2-inch. O. D. glass tube filter in use for four years at the Montebello filtration plant. It is charged with 24 inches of their mechanical filter sand to which the regular mechanical filter wash is applied. It is used to make quick tests of chemicals preceding their use in the plant and has effected quite a saving thereby.

Allen Hazen[2] states that "The results at Lawrence (Mass.) have shown that with very fine sands 0.09 and 0.14 m.m., and 4 to 5 feet deep, with a quantity of water which can practically be made to pass through them, it is almost impossible to drive more than an insignificant fraction of the bacteria into the effluent. Still finer materials, 0.04 to 0.06 mm., as far as could be determined, secured the absolute removal of all of the bacteria."

The reverse flow, filter washer and positive and negative head of 15 feet, makes practical the use of the above fine sands at high rates of flow.

[2] Page 32 of his work on "The Filtration of Public Water Supplies."

ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

Key: American Journal of Public Health, **12:** 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

The Necessity for the Continual Inspection of the Water in Swimming Pools. JACK J. HINMAN, JR. Swimming, June, 1925, 2. Conclusions result of daily examinations of water in swimming pools at University of Iowa; importance of continual inspection and examination stressed. Heavy application during early evening after pool has been vacated is most effective method of chlorination.—*R. E. Thompson.*

Objectives in Sewage Treatment. JACK J. HINMAN, JR. Bull. **69:** Eng. Expt. Dept., Iowa State College, Ames. December 24, 1924. 11 pp. General discussion of sewage treatment in relation to contamination of public water supplies, pollution of drinking water for animals, and use of streams for recreational purposes. Scarcity of reliable information relative to quality of water for cattle and desirability of extending our knowledge in this direction is emphasized.—*R. E. Thompson.*

Effect of Hard Water on Peas. A. E. STEVENSON. Canning Age, 1923, February, 21–2. From Chem. Abst., **17:** 1849, May 20, 1923. Effect of hard water on peas in various steps in canning process discussed. Many grades of sodium chloride have calcium and magnesium content sufficient to have distinctly hardening effect on peas. Sodium chloride with calcium content of more than 0.25 per cent as calcium carbonate should not be used.—*R. E. Thompson.*

Mechanical Appliances for Pumping Chemical Solutions. A. K. FISCHER. Am. Dyestuff Rep. **11:** 301–6, 339–44, 349–52, 401–4, 1922. From Chem. Abst., **17:** 353, February 10, 1923. Illustrated general article.—*R. E. Thompson.*

The Chemical Treatment of Condensing Water. L. L. ROBINSON. Elec. Times, **61:** 607–8, 1922: Science Abstracts, **25B:** 579–80. From Chem. Absts., **17:** 1854, May 20, 1923. By chlorinating surface waters used for cooling purposes, algae and other gelatinous growths giving rise to troubles in condensers were inhibited. Better vacuum was maintained and less circulating water used. Chloronome chlorinating apparatus is described.—*R. E. Thompson.*

Kestner System for the Degassing of Boiler Feed Water. ANON. Iron Coal Trades Rev., **106:** 84–5, 1923. From Chem. Abst., **17:** 1854, May 20,

1923. Oxygen is removed by finely divided steel, specially prepared both in respect to chemical composition and physical condition. Advantages are: Heat in blow-down water is conserved; concentration of salts in boiler is limited to predetermined figure; salts contained in blow-down water are usefully employed in softening make-up water; blow-down water itself after separation of contained crystallizable salts and suspended matter is returned to boilers; all scale-forming salts are removed outside boiler; corrosion in boiler, economizer, and pipe connections is eliminated.—*R. E. Thompson.*

Analysis by Temperature Changes. D. M. STRICKLAND. Metal Ind., **20:** 339–40, 1922. From Chem. Abst., **17:** 1603, May 10, 1923. Thickness of zinc coating on galvanized articles can be determined by measuring rise in temperature caused by solution of zinc from definite area of sample in definite volume by hydrochloric acid. Rise in temperature multiplied by an experimentally obtained conversion factor gives weight of zinc. Temperature must be determined to 0.1°.—*R. E. Thompson.*

Does Nitrification Occur in Sea Water? C. B. LIPMAN. Science, **56:** 501.3, 1922. From Chem. Abst., **17:** 1657, May 10, 1923. Experiments showed that nitrifying bacteria are either absent from sea water or they cannot function in solution of such concentration. Since it will be shown in subsequent paper that bacteria can withstand high salt concentrations the first supposition is probably correct. Calcareous sand underlying same sea water, and therefore in equilibrium with it, contained vigorous nitrifying organisms.—*R. E. Thompson.*

Alkalimetric Determination of Magnesium and Calcium Salts. WILLSTÄTTER and E. WALDSCHMIDT-LEITZ. Ber., **56:** 488–91, 1923. From Chem. Abst., **17:** 1604, May 10, 1923. If slight excess of 0.1 N sodium hydrate is added to solution of magnesium salt and then sufficient alcohol to make solution 66–75 per cent alcohol, excess sodium hydrate can be titrated with acid, using 10 drops of 0.5 per cent alcoholic thymolphthalein as indicator for each 100 cc. of liquid. Calcium can be titrated similarly if, instead of alcohol, sufficient acetone is added to make solution 85–90 per cent acetone. In solution containing both calcium and magnesium the latter can be titrated alone by using alcohol to decrease solubility of magnesium hydroxide and in another portion both can be determined by using acetone to keep both magnesium and calcium hydroxides insoluble.—*R. E. Thompson.*

Corrosion in Condensers. ERNEST BATE. Engineering World, **23:** 16–8, 1921; J. Inst. Metals, **26:** 534. From Chem. Abst., **17:** 1615, May 10, 1923. Causes of failure of tubes at two power stations in Sydney, N. S. W., described. At first station pitting caused failures in 2–3 per cent of tubes per year, due to unsuitable composition and to American practice of prolonged annealing at 400°. At second station there was little pitting, but end corrosion and dezincification occurred. Only serious pitting was in tinned brass tubes. Experimental tests showed that hard-drawn copper tubes failed by pitting at 80 times rate of tinned brass tubes, 70 per cent being removed

within 1 year. Dezincification with patent brass tubes was 100–200 per cent worse than with Br. Admiralty brass. Brass ferrules (60:40 composition) were dezincified, whereas Br. Admiralty compound was unaffected. With 4-pass condenser percentage of failures was approximately proportional to square of velocity of flow. Unusual fern-like copper redeposition at tube-ends, ferrules, tube-plates and end-boxes was caused by condenser standing in foul sea water for 3 weeks.—*R. E. Thompson.*

The Determination of Hardness in Technical Waters. FRANZ KANHÄUSER. Chem.-Ztg., **47:** 57–9, 1922. From Chem. Abst., **17:** 1680, May 10, 1923. Blacher method, as follows, is recommended. Determine alkalinity in 100 cc. (dilution is made in case of very hard water) with 0.1 N hydrochloric acid using methyl orange as indicator; destroy methyl orange color with bromine water; remove carbon dioxide and halogens; add 0.5 cc. of 1 per cent alcoholic phenolphthalein and titrate with carbonate-free 0.1 N sodium hydroxide; remove color with 0.1 N hydrochloric acid and titrate immediately with 0.1 N potassium palmitate. Number of cc. of palmitate multiplied by 2.8 equals hardness in German degrees. If N/28 palmitate is employed, degrees hardness is equivalent to cc. used. Iron and manganese do not interfere as they are precipitated as hydroxides at phenolphthalein neutral point. The Clark soap method gives low results for waters containing organic material. For heavily contaminated waters it is recommended therefore that the water be evaporated, residue baked, and then brought into solution with acid. Blacher method gives good results with water of high organic content, but if highly colored it may be necessary to remove color by adding bromine water or by evaporation with few drops of aqua regia if phenolphthalein titration is interfered with. The palmitate solution may be used to determine sulfate content as follows: precipitate sulfate in phenolphthalein-neutral and carbon dioxide-free water with excess 0.1 N barium chloride; back titrate excess and total hardness with palmitate; calculate sulphate from palmitate solution used and from amount used for hardness determination.—*R. E. Thompson.*

Sterilization of Small Volumes of Water by Means of Ozone. S. BRUÈRE. Tech. sanit. munic., **17:** 268–70, 1922; cf. C. A., **16:** 1628. From Chem. Abst., **17:** 1680, May 10, 1923. Two types of Van der Made sterilizers for treating respectively 30 and 150 l. per hour described. Test of small apparatus showed reduction from 2716 bacteria per cc. (including B. coli communis and putrefactive bacteria) to 2 (B. subtilis), and of larger apparatus from 2345 per cc. to 8 (Mucor mucedo and B. subtilis).—*R. E. Thompson.*

The Colloidal State and Its Relation to the Filtration of Drinking Water and the Purification of Waste Waters. PAUL RAZOUS. Industrie chimique, **10:** 57–60, 1923. From Chem. Abst., **17:** 1681, May 10, 1923. Effects of surface tension, electric charge on particles, and viscosity of medium on persistence of suspensions, and application of these principles to coagulation and filtration of water outlined.—*R. E. Thompson.*

The Determination of Alkali in Water and Nutrient Bouillon. H. NOLL. Z. Hyg. Infektionskrankh, **96**: 172–90, 1922. From Chem. Abst., **17**: 1812, May 20, 1923. Titration using methyl orange or, after removal of carbon dioxide, phenolphthalein or azolitmin, was found satisfactory. Iron, silicates, and humin influence accuracy of titration, giving rise to high results. For turbid solutions spotting on litmus paper was found suitable.—*R. E. Thompson.*

Influence of the Salinity of Sea Water on the Assimilation of Chlorophyll by Algae. R. LEGENDRE. Compt. rend. soc. biol., **85**: 222–4, 1921; Physiol. Abstracts, **7**: 148. From Chem. Abst., **17**: 1819, May 20, 1923. Assimilation by *Ulva lactuca* and by *Fucus serratus* increases with decreasing density of sea water up to maximum when density is 1.010. In more dilute solutions assimilation ceases. Content of carbonate and bicarbonate may be a factor. —*R. E. Thompson.*

The influence of Reaction on Fresh Water Infusoria. W. G. SAVICH. Bull. Inst. Exptl. Biol. (Moscow), **1**: 36–48, 1921; Physiol. Abstracts, **7**: 165. From Chem. Abst., **17**: 1845, May 20, 1923. For several types optimum was an acid medium (pH 6.23–6.97); for others, an alkaline medium (pH 7.16–9.18). To former belong *Frontonia, Bursaria,* etc.; to second belong *Nassalu, Paramecium, Stentor,* etc. Several kinds (*Dileptus*) can live well within wide limits (pH 4.49–9.18). Favorable influence of small admixtures of calcium is noted. Osmotic pressure does not play great part in well-being of infusorians.—*R. E. Thompson.*

Respiration of Fish and the Reaction of the Water. FRANCE GUEYLARD and MARCEL DUVAL. Compt. rend. soc. biol., **88**: 180–2, 1923. From Chem. Abst., **17**: 1845, May 20, 1923. Irrespective of initial pH value, neutrality is reëstablished either through carbon dioxide or through sodium carbonate given off by fish.—*R. E. Thompson.*

Double-Stroke, Deep-Well Pump. Eng. News Rec., **94**: 873, May 21, 1925. Pump which eliminates "dead stop" of water column at end of each stroke, developed by A. D. Cook, Inc., Lawrenceburg, Ind., described briefly.—*R. E. Thompson.*

Exchequer Dam Construction Plant Built in Narrow Canyon. Eng. News Rec., **94**: 880–4, May 28, 1925. Construction of Exchequer Dam on Merced River in California for conserving flood waters for irrigation and incidentally for generation of power, is described in some detail and illustrated. Construction plant is of interest in having been designed for very restricted space, it being not feasible to provide more than one day's storage for aggregate and two days' for cement. The dam will be 330 feet in height and, including powerhouse and spillways, will contain 400,000 cubic yards of concrete.—*R. E. Thompson.*

Water Works Improvements at Kearney, Neb. ELMER L. FERGUSON. Eng. News Rec., **94**: 884–5, May 28, 1925. Recent improvements to Kearney water works are described briefly, including circular concrete reservoir of 1 mg. capacity and 3 new wells equipped with 1000 g.p.m. centrifugal pumps driven by 60 h.p. electric motors actuated by 600 h.p. Diesel oil-engine power plant.—*R. E. Thompson.*

Flexible Filing System for Engineering Data. JULIAN MONTGOMERY. Eng. News Rec., **94**: 892–3, May 28, 1925. Simple filing system, consisting of legal-size filing drawer and extensible file pockets, in which literature and other data may be filed in alphabetical order, is described and illustrated. —*R. E. Thompson.*

Flow of Water in Tulsa 60-inch and 54-inch Concrete Pipeline. FRED C. SCOBEY. Eng. News Rec., **94**: 894–7, May 28, 1925. Tests of Spavinaw reinforced-concrete aqueduct, Tulsa, Okla., are described in detail and illustrated. Results were highly satisfactory. Value of C for Hazen-Williams' formula was 145.4 for 6.6 miles of 60-inch pipe having 29 bends aggregating 455.7; 152.4 for 15.3 miles of slightly sinuous 60-inch pipe; and 152.1 for 4 miles of nearly straight 54-inch pipe. Corresponding values of n in Kutter's formula were 0.0111, 0.0107, and 0.0106, and of C_s in Scobey's formula 0.386, 0.402, and 0.409, approximately 10 per cent higher than value of 0.370 previously suggested by author for "glazed interior pipelines." Values for other formulas and also loss-of-head values for entire reaches of pipe, bends alone, and Venturi meter are included.—*R. E. Thompson.*

Cofferdam Used in Bell Holes for Jointing Pipe in Wet Trench. SAMUEL P. BAIRD. Eng. News Rec., **94**: 902, May 28, 1925. Brief illustrated description.—*R. E. Thompson.*

Joint Between Penstock and Saddles Made of Asbestos Paper. Eng. News Rec., **94**: 903–4, May 28, 1925. Brief description of joint between penstocks and concrete saddles in line serving Moccasin Creek plant on Hetchy Hetchy project.—*R. E. Thompson.*

Newark, Ohio. Eng. News Rec., **94**: 930, June 4, 1925. Brief financial data on Newark, O., supply, which is derived from Licking River. Total valuation based on cost is $770,192.58, of which $448,205 represents mains and services. 1923 report shows plant revenue $137,658; expense $90,889; net gain $46,769, an increase of $13,000 over previous year. Re-appraisement of all services, it is believed, would show valuation of at least $400,000 higher. —*R. E. Thompson.*

Rope Net in Surge Chamber Safeguards Workmen. Eng. News Rec., **94**: 990, June 11, 1925. Rope net made on job at Moccasin Creek plant on Hetchy Hetchy project was suspended in concrete surge chamber to prevent accidents during construction. Surge chamber stands 48 feet above ground level and

inside depth is 160 feet. Use of net not only eliminated danger of accidents but enabled men to work more rapidly with added confidence.—*R. E. Thompson.*

Dam and Power-House Reconstruction at Marinette, Wis. D. GRAHAM MOON. Eng. News Rec., **94:** 973–6, June 11, 1925. Construction of concrete dam to replace old rock-filled timber crib structure situated about ¾ mile below Marinette Dam on Menominee River, described and illustrated. —*R. E. Thompson.*

Probability Methods for Rainfall and Runoff. S. L. MOYER. Eng. News Rec., **94:** 906, May 28, 1925. Brief mathematical discussion of probability methods, in which common error in selection of magnitudes indexing the chance is pointed out.—*R. E. Thompson.*

Diesel Engine Developments. R. H. BACON. Eng. News Rec., **94:** 998, June 11, 1925. Recent mechanical improvements in Diesel engine which have increased its dependability discussed and two-cycle solid injection type and its operation described and illustrated.—*R. E. Thompson.*

Determining the Energy Lost in the Hydraulic Jump. J. C. STEVENS. Eng. News Rec., **94:** 928–9, June 4, 1925. Mathematical discussion of hydraulic jump which occurs when condition of flow passes from low to high stage across critical depth. Formula for energy loss, in terms of initial energy present, is derived.—*R. E. Thompson.*

Treatment and Filtration of Water. H. W. CLARK. Eng. and Contr., **63:** 291–4, 1925. Observations and tests on loaded slow sand filters are described.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

The Swimming Pool and the Engineer. WILLIAM S. FRANKLIN. Eng. & Contr., **63:** 321–4, 1925. Canvas bulkhead which serves as automatic emptying, scrubbing, and refilling device is described.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Metering the Water Supply of the City of Chicago. HENRY A. ALLEN. Engr. & Contr., **63:** 517–25, 1925. Causes and effects of waste are discussed and a comparison made of water consumption and of death rates in various cities.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Applying Copper Sulphate. ANON. Engr. & Contr., **63:** 125–26, 1925. Public Works, **56:** 55, 1925. Dose of 0.05 p.p.m. applied on three days from spraying machine was effective.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Vest Station—Charlotte Water Works. EARLE G. MCCONNELL. Public Works, **56:** 110–14, 1925. Eight million gallon capacity filter plant, with novel rate controller and original filter bottoms, is described.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Germicidal Action of Ultra Violet Rays. ANON. Public Works, **56**: 114, 1925. Tests of U. S. Bureau of Standards with short wave lengths on Bact. coli are reported.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Breaks in Baltimore Water Mains. V. BERNARD SIEMS. Public Works, **56**: 115–16, 1925. Engr. & Contr., **63**: 529–30, 1925. Breaks are caused by vibration from heavy trucks, disturbance of ground, and defective pipes. —*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Spavinaw Water Supply Project. W. R. HOLWAY. Public Works, **56**: 1–5, 1925. System to bring water 55 miles to Tulsa, Okla., is described.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Preventing Waste of Water by Private Fire Connections. Fire & Water Eng., **75**: 1373, June 25, 1924. 1924 report of committee of National Fire Protection Assoc. on private fire supplies from public mains. Loss of water from fire systems are now being controlled as follows: (1) Separation of pipes supplying water for industrial purposes from fire service pipes within the property. (2) Sealing outlets, such as hydrants and sprinkler drains. (3) Using detectors, or fire service meters, on fire service connections. Methods 1 and 2 have been longest in use and will doubtless take care of large majority of plants having modern systems of automatic sprinklers. Method 3, use of detector, consisting of weighted check valve with small bypass meter, has been in use for several years in a few large cities with satisfactory results. Within the year further improvement of this detector has been made and laboratory tests for determining degree of accuracy to be expected from it, indicate that up to 25 gallons per minute can be detected with same accuracy as with an ordinary small size meter. For the comparatively few cases which cannot be covered by any of above methods meters may be permitted, but these should be of fire service type, specially designed to offer minimum obstruction to large flows.—*Geo. C. Bunker.*

New Water Facilities at Russell, Ky., Insure Adequate Supply. ANON. Railway Engineering and Maintenance, May, 1924, page 191. Chesapeake and Ohio R. R. recently completed extensive improvements to water station facilities at Russell, Ky. Present consumption is 1½ m.g.d.; new facilities provide for 2½ m.g.d. Duplicate triplex installation and emergency steam station were replaced by direct connected electrical centrifugal pumps in 20 x 55 feet dry well. Sump and intake tower corrected suction conditions. 40 feet diameter by 74 feet high standpipe provides additional storage and assists in clarification of treated water from 80,000 gallons per hour Graver Type K lime and soda ash water softening plant. Sodium aluminate is used to aid clarification. Detail piping plans and photographs are shown.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Huntington, W. Va., Water Facilities Have Interesting Features. ANON. Railway Engineering and Maintenance, **21**: 4, 263, 1925. Chesapeake and Ohio R. R. recently completed improvements at its Huntington, W. Va.,

water station and placed in service largest intermittent type treating plant in Railway service. Triplex pumping units have been replaced by electrically driven centrifugal pumps with intake sump and drift lines. 200,000 gallon elevated steel tank provides additional storage. Water supply is secured from Guyan River which is badly polluted at times with acid drainage from coal mines and carries heavy burden of mud and sand during wet season. Treatment is carried out in two steel tanks, 54 feet diameter by 30 feet high, which are used alternately for batches of 500,000 gallons. Lime and soda ash are used for softening, with sodium aluminate to aid in clarification when necessary. Floating suctions are connected to automatic transfer pumps to distribution system. Rated capacity is 3 m.g.d. Detail piping diagram and photographs are shown.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Lowering Pumping Costs in Small Water Works. L. V. ARMSTRONG. Fire & Water Eng., **76**: 11, July 2, 1924. Municipal water works of Westbury, Long Island, was originally equipped with 2 triplex pumps driven by vertical engines designed for operation with anthracite producer gas; difficulties of operation resulted in change to gasoline; rising prices of gasoline and pump troubles forced another change to kerosene engines and air lift. By 1922, engines needed expenditure of several thousand dollars to fit them for peak-load requirements of summer. Commissioners purchased Diesel pumping unit, capacity 500 gallons per minute, manufactured by Ingersoll-Rand Co., consisting of single cylinder, horizontal, 4 cycle, solid injection oil engine direct connected to double acting, single stage I.-R air compressor; a short belt from one of engine flywheels driving Cameron single stage, centrifugal pump. Compressor furnishes air for lifting water from wells into catch basin from which pump delivers it into elevated water tank. Kerosene engines are retained as reserve units. New pumping unit has been operated for nearly a year without any change in force and engineers have had no trouble with it. Cost of pumping per 1000 gallons is 4.8 cents. Average daily pumpage is 400,000 gallons. Illus.—*Geo. C. Bunker.*

Gauging the Stream Flow of a Surface Water Supply. WARREN E. HALL. Fire & Water Eng., **76**: 59, 1924. A short paper on stream gauging stations. Cost of installing varies from $25 for simple rod gauge to $1000, or even $2000, for the more elaborate permanent automatic gauges. Operating costs range from $150 to $500 per year depending on number of visits by engineers. Daily observers' salaries vary from $5 to $15 per month. Office costs, borne by Survey, are between $60 and $100. Geological & Economic Survey in North Carolina is prepared to furnish engineers who will examine local conditions, plan equipment necessary to give accurate results, supervise installation, make discharge measurements and compute and compile data. The co-operating municipality would have to pay for permanent equipment, including labor and material, and also for field expenses and salary of local observer. Illus.—*Geo. C. Bunker.*

Get the Filter Plant Men to Work in Harmony. C. ARTHUR BROWN. Fire & Water Eng., **76**: 63, July 9, 1924. Discussion of "lack of understanding" between mechanical and chemical operators of filter plants. Ordinary water purification plant is complicated proposition and requires continuous and unceasing care, both in operation and maintenance, demanding therefore considerable mechanical ability. Likewise, an equal amount of chemical skill and knowledge must obtain. Unless both are present, results can not be satisfactory. The chemist must strive for greater or lesser ability as engineer, and, similarly, the mechanical operator should obtain a working knowledge of such chemistry and bacteriology as is required to successfully operate water purification plants. Just as the graduate chemist may find it difficult to attain knowledge of mechanical side, so also, the mechanical operator may find it difficult to attain proficiency on scientific side. Man with knowledge of both is more charitable in his understanding of value of each. Other things being equal, successful operation of any filter plant must depend, primarily, upon experience, skill, knowledge, and judgment of operator; state can ill afford to hamper plants by any action which would hinder development of successful operators.—*Geo. C. Bunker.*

Characteristic Curves in Calculating Pump Action. F. JOHNSTONE-TAYLOR. Fire & Water Eng., **76**: 155, July 23, 1924. Discussion of some characteristics of centrifugal pumps of orthodox and of self-regulating types. Illus.—*Geo. C. Bunker.*

Calling the "Doctor" for the Water Works System. HENRY C. HILL. Fire & Water Eng., **76**: 159, July 23, 1924. Generally speaking, water works should be carefully examined from time to time by consulting engineer in order to take care of changing conditions and eliminate obsolete features. Quantity and quality of water, power, pumps, and fire protection are briefly discussed in this connection.—*Geo. C. Bunker.*

Changing Old Water Works into a Modern System. STANLEY H. WRIGHT. Fire & Water Eng., **76**: 168, July 23, 1924. Description of improvements at Hendersonville, N. C. At junction of two creeks, at elevation of 2450 feet above sea level, concrete intake dam, 180 feet long and 22 feet high, was built. 16-inch c.i. pipe line, 77,000 feet long, capacity 2,300,000 gallons per day, carries water by gravity, under head of 117 feet, to new distribution reservoir on hill one mile west of city. Only about 3 of a total of 7020 pieces of pipe failed under test; there was one serious joint blow out; 3 per cent of total number of joints showed slight sweating or trifling leakage which required recaulking. The elliptical reservoir is divided into two sections by wall, so that water may be taken from either or both. Capacity of each section is 2.5 million gallons, equal to 6 days' supply at present time. Distribution system consists of 16-inch pipeline from reservoir to Main St., with 4, 6, and 8-inch laterals. More than 7 miles of new 6-inch pipe and 1 mile of 8-inch pipe have been laid. Fire hydrants have been set not more than 500 feet apart. Illus.—*Geo. C. Bunker.*

Looking Forward to a Future Water Supply. JOHN H. QUENSE, JR. Fire & Water Eng., **76**: July 30, 1924. Description of extension of water supply of Seattle, Washington, made necessary by rapid growth in population, now estimated at 350,000. Present supply, taken from Cedar river, the outlet of Cedar lake, is conveyed to reservoirs and stand pipes in city, with total storage capacity of 270 million gallons, through 2 wood stave pipe lines, of 44-inch and 60-inch diameter. Last year a 66-inch steel pipe line, parallel to these was completed and connected temporarily to the wood lines 1½ miles from north end of Lake Youngs. The Lake Youngs development embodies intake in lake near north end, valve well on north shore, concrete tunnel, controlling works, and 3 steel pipe lines connecting to existing lines. To complete scheme, conduit will be built later on from present intake in Cedar river to Swan lake, thereby eliminating 10-mile section of 44 and 60-inch wood pipe lines. The successful bid for work was $1,210,759. Intake is rectangular concrete structure on lake bottom from which runs concrete conduit, 8 feet inside diameter and 1 foot thick, to concrete valve well with 7 x 7 feet rectangular sluice gate which may be either electrically or hand operated. From well, concrete lined tunnel, 8 feet in diameter and 12,300 feet long, runs to controlling works, ending in steel plate wye anchored to tunnel lining by 300 feet of steel pipe 106 inches in diameter imbedded in the concrete. Wye leads to 2 screening tanks each 30 feet diameter and 65 feet high. Inflowing water is conveyed by concrete funnel to underside of horizontal screens of ¼-inch square mesh No. 14 B.W.G. brass wire. Increased cross-sectional area reduces velocity of flow through tanks to about ½ foot per second. Water leaves tanks through centrally placed steel funnels connecting to steel plate header from which 3 steel pipe lines, 48, 60, and 66 inches, respectively, convey it to city. Tunnel will have capacity of about 231 second feet, which should be sufficient for population of 750,000, or for 30 years. Illus.—*Geo. C. Bunker.*

Water Supply Problems of Atlanta, Georgia. PAUL H. NORCROSS. Proc. Amer. Soc. Civ. Eng., **51**: 6, 969-98, August, 1925. Supply is derived from Chattahoochee River. Works include 48-inch intake conduit, steam-driven river pumping station operating against head of 275 feet, and three conduits 30, 36, and 48 inches in diameter, respectively, and 18,500 feet long. Two raw water settling reservoirs have combined capacity of 393,000,000 gallons, and 5 coagulating basins have combined capacity of 13,000,000 gallons. New mixing chamber will be constructed. Rapid sand filters are of two types. Original, of pressure type, contains 48 units with combined capacity of 21,000,000 gallons daily; new, of gravity type, 7 units with same combined capacity. New covered clear water reservoir has capacity of 10,000,000 gallons. Brief history of development of Atlanta's water supply is given, including plans and description of new filter plant. Chattahoochee River water is very low in dissolved solids and hardness, former being about 32, and latter about 11 p.p.m. Effluent from pressure plant is connected to conduit from new clear water basin to high-service pumping station. Improvements at Hemphill Ave. pumping station consist of new chimney, remodeling steam headers, equipping boilers with superheaters and mechanical stokers, remodeling

suction and discharge headers, and installing new 30,000,000 gallon turbo-centrifugal pumping unit.—*John R. Baylis.*

Index of Analyses of Natural Waters in the United States. W. D. COLLINS and C. S. HOWARD. U. S. Geol. Survey Water Supply **560-C**, pp. 53–85, May, 1925. Bibliographic list, by states, of publications of Federal and State reports of geological surveys, experiment stations, and health departments and also of journal articles that contain collections of water analyses, considering primarily analyses that include determinations of mineral constituents.—*David G. Thompson.*

Ground Water in Pashimeroi Valley, Idaho. OSCAR E. MEINZER. Idaho Bureau of Mines and Geology Pamphlet No. 9: February, 1924, 35 mimeographed pages, illustrated. Report of investigation made in coöperation with U. S. Geological Survey to determine feasibility of developing artesian or other ground water supplies for irrigation. Valley is one in which no drilled wells exist. Mountain streams furnish abundant supply of water in spring months, but it is quickly either carried out of basin or absorbed by porous sand and gravel. Springs, an increase in stream flow in lower part of basin, and certain water loving types of vegetation indicate that considerable water can be obtained from wells, although conditions are not favorable for artesian supplies. Methods suggested for increasing available water supply are improvement of distribution systems, building of reservoirs, and spreading of waters to promote ground water recharge.—*David G. Thompson.*

Temperature of Water Available for Industrial Use in the United States. W. D. COLLINS. U. S. Geol. Survey Water Supply Paper **520-F**, pp. 97–104, 2 maps and figures, April 24, 1925. Temperature of ground water at depth of 10 feet may range from 10° above to 10°F. below mean annual temperature; between 30 and 60 feet below ground surface it is generally 2° to 3° above mean annual temperature, and below that depth temperature increases on an average of about 1°F. for each 64 feet of depth. Relation between temperature of surface water and air temperature is more variable than that between temperature of ground water and air temperature. Difference may be due to such conditions as water carried from cool areas into warm areas, the return to streams in industrial districts of heated condensing water, or the slow change of temperature in deep bodies of water. These conditions are shown by graphs of air and water temperature at several localities. Two maps of United States are included showing by isotherms approximate temperature of water from nonthermal wells at depths of 30 to 60 feet, and approximate mean monthly temperature of water from surface sources for July and August.—*David G. Thompson.*

The Artesian Water Supply of the Dakota Sandstone in North Dakota with Special Reference to the Edgely Quadrangle. OSCAR E. MEINZER and HERBERT A. HARD. U. S. Geological Survey Water Supply Paper **520-E**, pp. 73–95, January, 1925. Illustrated. Review of results of uncontrolled draft

on part of artesian basin formed by Dakota sandstone and overlying shales which is considered the most remarkable basin in United States in respect to its great extent, long distance through which its water has percolated, and great original pressure in the formation. It is estimated that there are 16,000 to 18,000 artesian wells in North and South Dakota. Pressures as high as 200 pounds per square inch and flows as great as 4000 gallons a minute are reported for wells drilled in early eighties. Since then, as result of allowing wells to flow freely, head has dropped 250 to 300 feet (108 to 130 pounds) with consequent cessation of flow of wells in belt 5 to 10 miles wide, and great decrease in natural yield of wells in area of artesian flow. Nevertheless, specific capacity, or yield per foot of head, is about same as when head was greater. Despite considerable reduction in waste of water following passage of State law in 1921, decline in head was still in progress in 1923, showing that discharge was in excess of recharge. This condition would require withdrawal of some water from storage in region. Theory is advanced that such withdrawal was accompanied by compression of sandstone in which interstitial space was reduced by volume equal to that of stored water that was discharged.—*David G. Thompson.*

Dug Wells. L. A. GEUPEL. Monthly Bulletin. Indiana State Board of Health, **27**: 11, 169, November, 1924. Brief exposition of unsatisfactory sanitary quality of waters from dug wells. In year ending September 30, 1924, some 711 dug wells were examined in Indiana and 513, or 72 per cent, were found bad. Of wells less than 25 feet in depth, 88 per cent were found bad, and of wells of greater depth, 60 per cent.—*E. S. Chase.*

Many Household Water Filters are Inefficient. Weekly Bull. Cal. St. Bd. Health, **3**: 52, 205, February 7, 1925. Points out that, of household filters, a few are efficient in removing bacteria; but most do little more than prevent spattering of stream from faucet. Gives results of an investigation by Connecticut State Board of Health, summary of which is, that household filters with proper care have some advantages, but their usefulness is limited and in general extravagant claims as to their value are untrue.—*E. S. Chase.*

Polluted Water Causes Two Epidemics. Illinois Health News, **11**: 3, 67, March, 1925. Epidemics respectively of dysentery in Greenville, Ill., and of typhoid in Sterling and Rock Falls, Ill., due to infected water supplies. At Greenville, mains from supply wells are of vitrified tile instead of iron and pass over sewer at two or three points. Leakage from sewer found its way into water supply. Nearly 3000 cases of dysentery occurred. At Sterling and Rock Falls typhoid outbreak occurred among employees of one factory and was attributed to leaky cross-connection between Sterling water supply and polluted private supply of factory.—*E. S. Chase.*

Sanitary Engineering Work in the Tornado Area. H. F. FERGUSON. Illinois Health News, **11**: 5, 134, May, 1925. Account of sanitation measures put into effect by Sanitary Engineering Division of Illinois State Dept. Health subsequent to tornado of March 18, 1925, which devastated portions

of that state. At Murphysboro, supply is normally filtered and chlorinated; but due to heavy demand for fire use, filters had been by-passed and water pumped to mains which had been chlorinated only, with, however, triple dosage. At West Frankfort water had been taken from a stream and pumped without treatment. After the tornado, emergency chlorinator was installed. Many private water supplies from wells and cisterns were in use in devastated area. Many of the wells being open at top had various kinds of polluting material blown into them. All wells were disinfected with chloride of lime and better type of wells were posted for use and poorer wells placarded with danger signs. As a result of prompt emergency work, no outbreak of water-borne disease occurred.—*E. S. Chase.*

Protection and Development of Ground Water Supplies. ANON. Monthly Bull. Indiana St. Bd. Health, **28**: 8, 113, August, 1925. "Code of Principles" taken from report of committee on sanitary control of ground water supplies to conference of State Sanitary Engineers in Louisville, April 25–27, 1925. Ten principles are stated, covering safeguards to wells, springs, mine water, and infiltration galleries.—*G. C. Houser.*

The Iodine Content of a Few of the Public Water Supplies of New Jersey. LEROY FORMAN. Public Health News (N. J. Dept. of Health), **10**: 6–7, 164, May–June, 1925. A study of iodine content of public water supplies of New Jersey is now being made, on account of attention lately given to relation of amount of iodine in water to prevalence of goiter. Of ten supplies examined, largest amount of iodine, 8 parts per billion, was found in water from deep wells at Princeton.—*G. C. Houser.*

Tri-State Water Treaty. W. L. STEVENSON. The Listening Post (Penn. Dept. of Health), **3**: 23, 22, February, 1925. On January 24, 1925, compact between states of Pennsylvania, New York, and New Jersey was signed by Commissioners appointed by Governors of the three states to negotiate a treaty concerning allocation and use of waters of Delaware River. Compact definitely sets forth that highest use of water resources of Delaware River is for public water supplies. Water of the river above Port Jervis is equally divided between all three states and below Port Jervis between Pennsylvania and New Jersey.—*G. C. Houser.*

Sanitation of Cistern Water Supplies. ANON. Quarterly Bull., Louisiana State Board of Health, **15**: 4, 210, December, 1924. In order to avoid contamination of cistern water supplies, cisterns should: (1) Be tightly covered. (2) Have inlet for water screened with copper or bronze wire having 18 meshes to inch. (3) Be provided with cut-off, by which first washings from roof may be diverted to ground and wasted. (4) Be watertight, particularly if cistern is underground.—*G. C. Houser.*

Iodin and Goiter in Macomb County, Michigan. E. F. ELDRIDGE. Public Health (Mich. Dept. of Health), **12**: 10, 328, October, 1924. Study of iodin-containing water supplies of Michigan has received attention of Michigan

Dept. of Health during past year. It was found that presence of iodin in a water supply was coincident with reduction in goiter incidence of that community. Iodin in Macomb county water supplies is, as a rule, insufficient to prevent goiter entirely. Such iodin evidently comes from an outcropping of the Berea sandstone.—*G. C. Houser.*

Forestry and Rainfall. ANON. Bulletin of Minnesota Federation of Architectural and Engineering Societies, **9**: 9, 11, September, 1924. Extracts from article prepared in 1921 by W. B. PATTON, long an eminent civil engineer of Duluth, entitled "A Study of Meteorological Conditions at Duluth," and from an article on "Forestry and Stream Flow" prepared by Major W. W. HARTS, Corps of Engineers, U. S. Army, for presentation before Engineering Association of the South, and published in its Proceedings, Vol. XXI, No. 1, page. 20.—*G. C. Houser.*

Drainage and Rainfall. E. V. WILLARD. Bull. of Minn. Fed. of Arch. and Eng. Soc., **9**: 10, 16, October, 1924. Letter discussing "A Study of Meteorological Conditions at Duluth" by W. B. PATTON, which was published in September, 1924, issue of Bulletin.—*G. C. Houser.*

Typhoid Fever Held Compensable under Workman's Compensation Act. (Decision of Maine Supreme Judicial Court). Monthly Bull. Indiana St. Bd. Health, **28**: 5, 69, May, 1925. Typhoid fever, contracted by an employee of state highway commission from drinking polluted water furnished him by commission while in its employ, is a personal injury by accident within the terms of Maine Workmen's Compensation Act, and therefore compensable. (Brodin's Case, 126 Atl. 829.)—*G. C. Houser.*

Preventing Simple Goiter. ANON. Public Health (Mich. Dept. of Health), **13**: 1, 15, January, 1925. It is universally agreed that iodin deficiency in soil and water is cause of simple goiter. In Michigan, soil and water are decidedly deficient in iodin, resulting in high percentage of thyroid enlargement. For supplying the iodin lacking in our diet, iodized salt is most effective and inexpensive method. Iodized salt put on market by Michigan salt companies contains 0.02 per cent of sodium iodide.—*G. C. Houser.*

Hard Water an Unnecessary Evil. E. F. ELDRIDGE. Public Health (Mich. Dept. of Health), **13**: 1, 17, January, 1925. Hard water is one of most disagreeable and expensive of household commodities. City of Lansing, with population of 75,000, has water supply that contains 380 p.p.m. of hardness. Author estimates annual loss in soap due thereto at $134,000. On the other hand, he estimates annual cost of softening the water by means of a municipal softening plant, including interest on original cost of plant, at only $103,300. —*G. C. Houser.*

The Relationship of Hard Water to Health. I. JOHN T. MYERS. J. Infect. Dis., **36**: 6, 566, June, 1925. Experiments carried out to determine whether hard water was possible factor in urinary concretion formation are described,

and results summarized as follows: Oxamide fed to rabbits produced only a slightly larger amount of solid material in urinary bladder when rabbits received hard water than when they were given distilled water; no definite relationship was observed between hardness of water intake and amount of calcification of cartilage blocks in bladders of rabbits in conjunction with either high, or low, calcium diet; no evidence has been found proving hard water to be etiologic factor in urinary concretion formation. **Relationship of Hard Water to Health. II. Effect of Hard Water on Growth, Appearance, and General Well-Being.** JOHN T. MYERS. J. Infect. Dis., 37: 1, 13, July, 1925. Summary of experiments: White mice on diet of grains and a natural very hard water showed no striking differences in growth or appearance from those on similar diet receiving distilled water; white rats exhibited no marked differences; young rabbits receiving hard water were 30 per cent heavier at age of 42 days than those receiving distilled water; a few dogs on a mixed diet and natural hard water grew faster and had better general appearance than similar dogs with distilled water; two calves receiving a moderately hard water were 20 per cent heavier at age of 8 months than similar pair receiving distilled water; several groups of chicks on grain diet and natural hard water gained from 20 to 40 per cent more during first few months of life than did similar groups on distilled water intake; in one instance experiment was continued for a year and chicks receiving distilled water did not catch up. In no instance did animals on distilled water develop better than those on hard water, but reverse was true under several conditions.—*A. W. Blohm.*

NEW BOOKS

Traité de Technique, Vol. 1, Approvisionment et Distribution de l'Èau. A. RUTOT, P. QUESTIENNE and F. PUTZEYS. Series edited by F. PUTZEYS and F. SCHOOFS. 8vo. 535 pages, 178 figs. Librairie Polytechnique, Ch. Boranger, éditeur, Paris and Liègo. (Rev. hyg., 47: 461, May, 1925.)—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

Analyse bacteriologique des eaux potables (Guide pour l'éxamen des eaux destinées a l'alimentation). P. MOLLIEX, expert chimiste prés des tribunaux, chimiste principal au Service de surveillance des eaux d'alimentation de la Ville de Paris. Preface by Dr. Pottevin. 1925. XII plus 192 pages. Le François, éditeur, 91 Bvd. St. Germain, Paris. (L'Eau, 18: 57, mai 15, 1925.) —*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

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